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The report examines the energy requirements and supplies (especially fossil fuels) needed to jointly meet both energy and air quality requirements in seven air quality control regions within the Northeast Corridor during the 1970-1975 period. The Northeast Corridor includes the east coast of the United States from Boston to Washington. This area encompasses all or at least a major part of the air qualit- control regions of Boston, Providence, Hartford, New York, New Jersey, Philadelphia, Baltimore, and Washington. The essential purpose of the study is to identify major gap areas in near term fuel use and projected supply requirements considering both the need for energy and the need for environmental protection. An equally important objective is to provide recommendations with respect to specific steps needed to be taken in order to fill energy gaps in an environmentally acceptable manner as revealed by the study.

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AN ANALYSIS OF THE ENERGY/FUELS SUPPLY AND DEMAND SITUATION IN SELECTED AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

by

THE FUEL POLICY STAFF
OFFICE OF PROGRAM DEVELOPMENT
OFFICE OF AIR PROGRAMS
ENVIRONMENTAL PROTECTION AGENCY

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1.1 Purpose. This report examines the energy requirements and supplies -- especially fossil fuels -- needed to jointly meet both energy and air quality requirements in seven air quality control regions within the Northeast Corridor during the 1970-1975 period. The Northeast Corridor (see map, page 4) includes the east coast of the United States from Boston to Washington. In this area are all or a major part of the air quality control regions of Boston, Providence, Hartford, New York - New Jersey, Philadelphia, Baltimore and Washington. The essential purpose of the study is to identify major gap areas in near term fuel use and projected supply requirements considering both the need for energy and the need for environmental protection. An equally important objective is to provide recommendations with respect to specific steps needed to be taken in order to fill energy gaps in an environmentally acceptable manner as revealed by the study.

1.2 Background. In the highly populated Northeast Corridor, substantial populations are exposed to concentrations of noxious pollutants already exceeding levels compatible with a healthy environment. Consequently, standards and regulations are now being set and enforced by some local and State jurisdictions on the quality characteristics of fuels utilized or permissible emissions. The entire area will be covered by standards and implementation plans for SO_2 by March 1972 with the stipulation that the air quality standards must be met by early 1975. Such actions will result in substantial quantities of fuels, as presently produced, being unacceptable for consumption unless their sulfur content can be reduced or SO_2 emissions can be curbed by stack gas cleaning.

These actions are being taken during a period when a number of national and international events have resulted in what has been termed an energy crisis. In less than a year, a national, as well as a world-wide fuel shortage has developed. The situation is caused by a combination of several factors. The first area is international in scope: an unstable political situation in the Middle East has resulted in reduced U. S. imports of low sulfur crude oil from the Mediterranean area; the Syrian pipeline has been cut, forcing Western European oil supplies to be delivered by tanker around Africa, and tanker capacity to meet European, as well as the United States oil needs, is not available.

Second, European requirements for all fuels and particularly for low sulfur fuels are increasing faster than had been anticipated.

Third, the domestic fuel supply situation is barely adequate because of a number of interrelated problems. Requirements for natural gas exceed production and some pipelines and utilities have not been able to take on new customers. The supply of natural gas, as measured by development of proven reserves, has been declining because of a lack of incentive to explore. Oil exploration, which sometimes leads to gas discoveries, has also suffered a reduction in incentive because of tax law revisions and the threat of added imports. Delays in construction of nuclear power plants have created greater requirements for coal and residual oil than anticipated. Coal mining manpower shortages, coupled by wildcat strikes caused problems for the industry, but coal production increased in 1970 by about 5%.

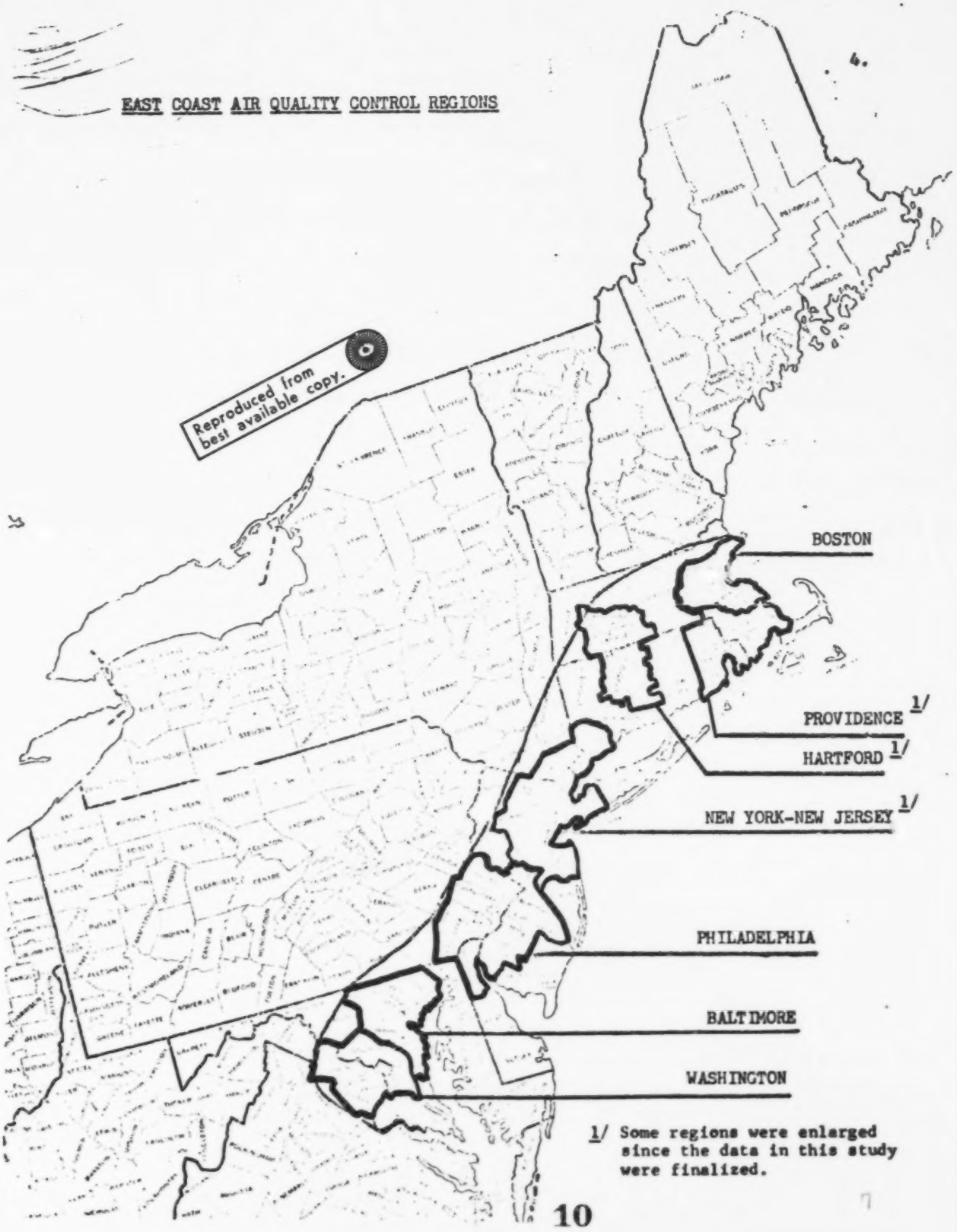
Finally, the implementation of air pollution control plans, especially in the Northeast Corridor, will further constrain the supply of both coal and oil because of allowable sulfur limits unless actions are taken to desulfurize the fuels or the stack gases. At the same time, many fuel consumers outside of the Northeast Corridor have vied to share in the limited supplies of low sulfur fuels, causing the Corridor to compete more intensively for these limited supplies.

1.3 Scope. The Northeast Corridor is defined to encompass the highly populated coastal area extending from Washington to Boston. As shown on the map on the next page, it includes the seven air quality control regions (AQCRs) of: Boston, Providence, Hartford-Springfield, New York-New Jersey Metropolitan area, Philadelphia, Baltimore and Washington -- as well as the intervening areas between these regions.

These seven air quality control regions were selected for study because they represent over 85% of the population in the Northeast Corridor. Since this study began, there have been other AQCRs designated within the Corridor; however, they are not included in this review since they are contained within the 15% population in the intervening areas with proportinately lower impact on the total fuel needs.

Another major reason for selecting these seven AQCRs for study is because they represent the best information currently available on fuel consumption by quality within the Corridor. Throughout the study, the term fuel "quality" refers to the sulfur content of the fossil fuels.

EAST COAST AIR QUALITY CONTROL REGIONS



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1/ Some regions were enlarged since the data in this study were finalized.

1.4 Methodology. The approach of the study described briefly herein represents several discrete, but related steps. First, energy requirements for the seven AQCRs were projected by energy type -- oil, gas, coal and nuclear -- and by fuel quality for the 1970-1975 period. These projections are based upon past trends and current and foreseeable developments. Fuel quality needs were based on existing fuel regulations. Second, an examination was made of supplies potentially available by quality to the AQCRs from both foreign and domestic sources. Third, a comparative evaluation was made of energy requirements and supplies to determine whether both energy and fuel quality needs can be met by specific fuels and nuclear energy. Finally, the nature and magnitude of energy and fuel quality gaps were evaluated with recommendations offered regarding specific steps needed for filling these gaps in an environmentally acceptable manner.

Fossil fuel use estimates developed jointly by the Division of Abatement and Division of Air Quality and Emission Data for the 1966-1969 period for the seven standard metropolitan statistical areas (SMSAs) -- which eventually became the centers for the AQCRs -- provided the data base. To adjust for subsequent growth and to compensate for the fact that the seven AQCRs eventually encompassed more area than represented by these earlier in-house SMSA figures, these fossil fuel use estimates were increased to approximate the 1970 situation. The estimated requirements for nuclear energy in the AQCRs is based on nuclear generation from installed and announced capacity in the Corridor

with the seven AQCRs estimated to receive 75% of the Corridor's nuclear energy during the 1970-1975 period.

Conditions surrounding fuel supplies are more uncertain than requirements and only gross estimates of quality fuel supplies available to the AQCRs have been made. Supplies of residual fuel oil, for example, are highly dependent on the international political and economic climate.

The complex interrelationship between the development in the fuel supply and the needs for high quality fuel, including fuel requirements outside of the seven AQCRs makes it most difficult to draw precise conclusions about the balance of requirements and supply. Nevertheless, near-term trends in fuel quality needs in comparison to fuel availability make even a gross evaluation of conditions revealing for the 1970-1975 period.

1.5 Sources. In addition to information supplied by APCO and its contractors, the study has drawn upon the most recent data available from industry and other government sources. The variety of sources notably include: the Bureau of Mines, the American Petroleum Institute, the National Coal Association, the American Gas Association, the British Petroleum Company, the Independent Petroleum Association of America, the Federal Power Commission, the Atomic Energy Commission, the Chase Manhattan Bank, the Oil and Gas Journal, the Wall Street Journal, the Oil Daily and others.

1.6 Energy Requirements. Energy requirements is defined as that quantity of energy that consumers will require in their projected course of activity. Based on historical trends, the analysis points to an approximate growth rate of 5.5% per annum. In this study the projection

of requirements is based on a lower growth rate in the 1970-1972 period followed by acceleration in the rate of economic growth in the latter years, but averaging a 5.5% growth rate during the entire period 1970-1975 inclusive.

Given these conditions, Table 1 shows the growth in requirements for three primary years of interest of the study -- 1970, 1972 and 1975 with the data not only displayed in terms of Btus, but also on the basis of sulfur content classes or their equivalent. Table 1 indicates that more than 5.2 quadrillion Btus of energy were required in 1970. Of this total, petroleum products -- distillate plus residual fuel oil -- represent 60%. Natural gas, coal -- both anthracite and bituminous -- and nuclear provide 22%, 16% and 2% respectively. The sizeable capture of the market by residual fuel oil (38%) is indicative of the trend of the past few years toward those energy sources which are more readily available at lower costs and are able to meet fuel quality standards for sulfur in the absence of stack gas cleaning.

For 1972, a continued shift towards more environmentally acceptable energy types is foreseen. Requirements for petroleum products is expected to rise to 62% of the total followed by natural gas (23%), coal (9%), and nuclear (6%). It is noteworthy that nuclear's percentage share has tripled from 2 to 6% between 1970-1972, while coal's share has slipped from 16% of the 1970 total to only 9% by 1972. Because of coal's greater difficulty in meeting air quality standards, it is projected that residual

TABLE 1

REQUIREMENTS AND PERCENTAGE SHARES BY ENERGY TYPE AND SULFU
CLASSES IN SEVEN AIR QUALITY CONTROL REGIONS OF THE NORTH

	Requirements in Original Units			Requirements in 10^{12} Bt	
	1970	1972	1975	1970	1972
Total Energy Requirements	NA	NA	NA	5,244	5,706
Petroleum (10^6 Bbls.)	511	583	666	3,086	3,485
Distillate Oil .3% Sulfur 1/	189	193	219	1,095	1,119
Residual Fuel Oil					
0.3-0.5% S	0	216	275	0	1,298
0.51-1.0% S	86	174	172	524	1,068
More than 1% S	236	0	0	1,467	0
Total Resid	322	390	447	1,991	2,366
Natural Gas 1/ (10^9 cf)	1,173	1,318	1,570	1,173	1,318
Coal (10^3 Tons)	33,560	20,750	19,290	860	537
Anthracite .51-1.0% S	3,075	1,200	1,000	74	29
Bituminous					
.51-1.0% S	10,860	19,550	18,290	283	508
More than 1%	19,625	0	0	503	0
Total Bituminous	30,485	19,550	18,290	786	508
Nuclear Energy 1/ (10^3 MWH)	12,527	36,588	83,843	125	366

1/ Sulfur content is shown by percentage weight. Since nuclear generation adds no sulfur to the
insignificant amount, energy from these sources is considered to be part of the .5% or less s

2/ NA - not applicable.

3/ For conversion factors to Btus, see Appendix II, Table 1.

* Calculates to less than 1% of total energy demand for respective year.

TABLE 1

PERCENTAGE SHARES BY ENERGY TYPE AND SULFUR CONTENT
N AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

inal Units		Requirements in 10^{12} Btus[3/]			Percentage Shares by Energy Type		
72	1975	1970	1972	1975	1970	1972	1975
	NA	5,244	5,706	6,876	100%	100%	100%
	666	3,086	3,485	3,969	60%	62%	58%
	219	1,095	1,119	1,269	22%	20%	19%
	275	0	1,298	1,652	0	23%	24%
	172	524	1,068	1,047	10%	19%	15%
	0	1,467	0	0	28%	0	0
	447	1,991	2,366	2,700	38%	42%	39%
	1,570	1,173	1,318	1,570	22%	23%	23%
	19,290	860	537	582	16%	9%	8%
	1,000	74	29	24	1%	*	*
	18,290	283	508	476	5%	9%	7%
	0	503	0	0	10%	0	0
	18,290	786	508	476	15%	9%	7%
	83,843	125	366	838	2%	6%	12%

e nuclear generation adds no sulfur to the environment and natural gas contributes only an considered to be part of the .5% or less sulfur content class.

able 1.

r respective year.

fuel oil and nuclear generation will capture the major part of the market that would otherwise go to coal.

By 1975, when requirements for nuclear generation will have risen to 12% of the total, requirements for petroleum will have continued to rise, but its percentage share will have dropped to 58% (distillate - 19%, residual fuel oil - 39%). Requirements for natural gas and coal will have changed very little representing 23% and 7% respectively.

Along with the shifts in market shares is a comparable shift in requirements for energy of given sulfur content or quality. Based on the information in Table 1, the summary tabulation below points to a dramatic shift in requirements by energy "quality" between 1970 and 1972. In 1970, some 38% of the energy use was of fuels containing more than 1% sulfur while less than half of the use (46%) was of energy supplies containing .5% sulfur or less. In contrast, there will be no requirements in 1972 for energy supplies of more than 1% sulfur, while 72% will be for energy supplies of .5% or less by that time. Based on currently announced schedules of changes in fuel quality regulations, an additional rise in requirements for fuels with .5% sulfur or less to 78% will develop by 1975.

Requirements for Energy by Sulfur Content Classes[1/]

Sulfur Content Classes	1970	1972	1975
.5% or less	46%	72%	78%
.51% to 1.00%	16%	28%	22%
More than 1.00%	38%	0%	0%

1/ Since nuclear generation contributes no sulfur oxides to the ambient air and natural gas contributes almost none, they are included for purposes of this energy requirements tabulation in the .5% or less sulfur class.

1.7 Analysis of Energy/Fuel Supply and Requirements. For purposes of this study, energy supply is the quantity that producers are expected to be able to provide. Historically, price, not quality, has been the primary criterion for selecting fuel supplies. Nevertheless, efforts to protect the environment are making some fuels increasingly unacceptable and are resulting in major shifts in fuel use patterns. It has already caused many customers to seek new sources of low sulfur fuel and, in a number of cases, it has produced a rapid shift from traditionally low cost, but high sulfur fuels.

This section will briefly discuss the supply/requirements analysis of the specific fuels that comprise the energy sources for the seven air quality control regions. Fuel oil is considered first because it appears to be the only one for which significant short-term increases in supply can be obtained. After residual fuel oil, the areas of natural gas, including liquefied natural gas (LNG) imports, coal and nuclear energy are discussed.

At the end of this section, three summary tables are developed which show the supply/requirements relationships in the study area by fuel and fuel quality for the years 1970, 1972, and 1975.

1.71 Distillate Fuel Oil. Because distillate fuel oils supply and requirements are assumed to be in balance they are not discussed in any detail within this study. Requirements for distillate are expected to increase moderately over the period 1970-1975 from 189 to 219 million barrels. Domestic refineries should be able to meet these requirements

by minor adjustments in yield and with the additional support of current imports of distillate oils.

1.72 Residual Fuel Oil. Residual fuel oil supply and requirements for the seven AQCRs are based on the detailed analysis shown in Appendix 1. From the conditions summarized below, conclusions are drawn about the requirements/supply situation in the years 1970, 1972 and 1975.

It is estimated that in 1970, about 115 MM Bbls. of less than 0.5% resid was available from Caribbean and U. S. desulfurization and blending facilities. The seven AQCRs received approximately 86 MM Bbls. from these sources to meet their fuel quality requirements. In 1972, it is projected that this production will have reached about 273 MM Bbls. The seven AQCRs are projected to receive 106 MM Bbls. of less than 0.5% sulfur residual fuel oil in 1972 to meet a demand of 216 MM Bbls. This is a reflection of the claims of other areas for less than 0.5% sulfur resid. After 1972, no additional desulfurization or blending capacity is projected to be on line in the Caribbean or within the lower 48. Thus, capacity is assumed constant from 1972 through 1975 in this analysis. New capacity could be built with a 2½ or 3 year interval between decision to build and actual operation.

There is a possibility for immediate relief for part of this potential market for very low sulfur resid. This could be accomplished by a shift to topped crude (that is, crude oil which has been partially distilled to remove gasoline and other light fractions) by major resid users such as coastal utility plants. The Oil Import Administration has recently allowed topped crude to enter the U. S. provided the higher fractions are

either re-exported or used as boiler fuel in response to this winter's fuel situation. This measure is dependent upon receipt of low sulfur oil from Africa. However, this might require substantial price increases to draw this crude to the East Coast. Due to policies followed by governments in the Mediterranean area, low sulfur crude oil is not being produced at the capacity currently on line, and as a result, refinery output of low sulfur residual fuel oil is also limited.

A further possibility for relieving the fuel quality crisis in 1972 would be a shift in yield by domestic refineries to increase the yield of low sulfur resid. About 6½% of total U. S. refined products output in 1970 was residual fuel oil. Since on an average, U. S. crudes contain about 0.67% sulfur,[1/] it can be seen that the potential for production of low sulfur resid could be significant. It is estimated that the maximum potential refinery yield of residual oil is about 25%. This would, however, require shutting down all hydro cracking facilities and have three major consequences. It would decrease the output of gasoline from about 45% to 30% of crude oil processed and might require gasoline rationing or imports. Second, it would decrease the output of distillates from about 22% to 17% of crude and cause supply problems in the #2 fuel oil and diesel fuel markets. And third, it would require a price of residual fuel high enough to make it economic to carry the depreciation of the expensive hydro cracking facilities.

1/ C. M. McKinney and Ella Mae Shelton, Sulfur Content of Crude Oils of the Free World, U. S. Bureau of Mines Report of Investigations 7059 (Washington, U. S. Government Printing Office, 1967), p. 25 shows 0.67 percent sulfur in 1966.

Another factor limiting the supply of residual fuel oil is the tanker situation. Tanker movement of oil is restricted because of the tight market and high rates. If there is no sharp change in the worldwide political situation, this should improve gradually until about 1973 at which time tankers will no longer be a limiting factor in oil movement. Until this problem is resolved there may be a transportation bottleneck limiting the capacity to carry low sulfur feedstock and products to the Western Hemisphere. While reopening of the TAP line in Syria or the Suez Canal could change the shortage of tanker capacity into a surplus overnight, this is dependent upon political decisions by Mid-East governments.

The North Sea fields are another possible source of low sulfur resid. Tests from producing wells have shown a 0.18% sulfur content in the crude oil. It is not anticipated that there will be significant commercial production before 1974.

Based upon the assumption that there will be: (1) no preferential worldwide allocation of low sulfur fuels, (2) no resolution of the Mid East political conditions, (3) no significant change in domestic refinery yield, and (4) an increasing use of "topped" crude by power plants, the following situation is expected for 1972 and 1975 compared to the estimates for 1970.

1970 Total requirements of approximately 322 MM Bbls was supplied with a slight surplus.

1972 A total demand of 390 MM Bbls. will be met. However, the projected demand for 216 MM Bbls. in the fuel quality category of 0.5% or less will not be met and will result in a shortfall of 110 MM Bbls. This translates into a shortage of 661 10^{12} Btus. This is caused, in large part, by the more stringent fuel quality regulations in Boston, New York and Philadelphia.

1975 A total demand of 447 MM Bbls. will be met. Again, it will have to be at the expense of fuel quality considerations in the 0.5% or less sulfur category. A gap or shortfall of 35 MM Bbls. is anticipated. The increased demand from 1972 will be met, in large part, by use of topped crude by coastal refineries by conversion of fuel storage facilities and burners.

1.73 Natural Gas. The rate of increase in the supply of pipeline natural gas to the seven AQCRs from the southwestern producing States is expected to decline during 1970-1975. The reserve/production ratio in the continental United States is projected to decline from 14 to 1 to 10 to 1. If gas requirements in the seven air quality control regions grew at a rate of about 6% if additions to piepline supply do not correspondingly increase from discoveries in the lower forty-eight States, gas fuel requirements in the Northeast Corridor States will not all be supplied by the domestic natural gas industry. The only supplementary source is imported liquefied natural gas which may supply large volumes of gas in this area by 1975. Increased imports from Canada

will not provide any significant additional supply of natural gas to the seven AQCRs since this gas goes to the Midwest. Gasified coal, delivery of natural gas from the North Slope of Alaska, and nuclear stimulated gas supplies will not be available in commercially significant quantities to service the seven AQCRs during the period 1970-1975.

Based on projected requirements and supplies of natural gas, a growing fuel gap in this fuel source is foreseen for the 1970-1975 period. Because of its highly desirable air quality characteristics, requirements in the seven AQCRs for natural gas are expected to continue at an annual growth rate of 6% through 1975. At the same time, it is projected that gas supplies to the seven AQCRs will rise at a slower annual growth rate of 4½% per year during the 1970-1975 period. This rate is in contrast to the 5.9% per annum overall growth in supplies for the Northeast and Middle Atlantic States during the 1960-1968 period, and a Nationwide growth in demand of 9% for 1969. The seven AQCRs are assumed to have shared proportionately in that growth.

Imported liquefied natural gas (LNG) offers an opportunity to significantly increase supplies of low pollution fossil fuels to the seven air quality control regions by 1975. Significant quantities of LNG will eventually be introduced into Eastern Seaboard markets. Recently, the Federal Power Commission received applications to import 1½ billion cf of gas from Algeria and 425 MM cf from Venezuela in liquefied form. Imports of LNG are estimated to reach over one billion cubic feet* in

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* In natural gas equivalents.

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1971, about ten billion cubic feet by 1972 and over thirty billion cubic feet during 1975.

Several factors currently limit the availability of LNG imports. Liquefied natural gas tankers are in limited supply. Also, liquefication plants have to be built in both Algeria and Venezuela. There is a further problem of handling facilities at both loading and terminal points. Although these problems are currently being resolved it will require three to five years before enough cryogenic tankers and facility capacity at ports on both ends of the line will be available to utilize the full potential of the gas fields in these two countries.

The f.o.b. U. S. port of entry price of the gas will rise approximately 65 to 85¢ per M cf by 1975. Costs will increase, in part, due to the annual escalation clauses built into supply contracts and to increasing international LNG demand. The following conclusions are based on the above analysis as elaborated in the Appendix:

1970 Requirements were not met by domestic sources and only small volumes of imported LNG were available. This shortfall of 17 X 10^9 cf was met by additional supplies of other fuels.

1972 Although LNG imports are expected to appear in the amount of ten billion cf in 1972, this will not be enough to meet the requirements of 1,318 X 10^9 cf. The shortfall in supply will increase to 45 X 10^9 cf.

1975 Given the estimated annual requirements of 1,570 X 10^9 cf, supplies of natural gas are expected to reach 1,471 X 10^9 cf. This includes LNG imports of thirty billion cubic feet mainly from Algeria and Venezuela. This leaves a deficit in supply of 99 X 10^9 cf from this fuel source.

1.74 Coal. The national total supply of coal is expected to expand over the next five years at a rate of 4 to 5% per year. We assume that the total supply of coal for the seven AQCRs will equal or exceed the total requirements over the period of the study (1970-1975). This is believed to be reasonable in light of the many conversions from coal to the fluid fuels because of their lower air pollution potential.

To the extent that stack gas control technology is available, then supplies of higher sulfur coals can be used to meet environmental requirements and will be used to balance the fuel quality needs.

Since it requires approximately 2-4 years to bring a new coal mine into production, it is unlikely that productive capacity that is not now on line or under development will be able to satisfy the total requirements for low sulfur coal in 1972. However, by 1975, the requirements for 1% or less sulfur coal will be met, assuming that work is started immediately on several new low sulfur coal mines. This is based upon the estimate that the supply of low sulfur coal can be increased at the rate of 8% per year from 1970 production figures, and includes coal with its sulfur content reduced by washing.

In spite of the fact that no data exist to permit conventional analysis of the relationships between supply and requirements for this area by sulfur content of the fuel, an empirical method based on available data and a large measure of judgment has been developed to estimate the supply and requirements for low sulfur coal as discussed in the study.

The following are the conclusions based on this analysis:

1970 The estimated requirements of 13,935,000 tons of 1% or less sulfur coal is expected to be met, but not without the possibility of some spot shortages.

1972 The projected requirements of 20,750,000 tons of 1% or less sulfur coal will not be met by the projected supply of 18,350,000 tons. There will be a shortfall of about 2.4 million tons during 1972.

1975 There will be a slight decrease in demand to approximately 19,290,000 tons of 1% or less sulfur coal. It is expected that supply will have continued to grow at a rate to more than match this demand.

1.75 Nuclear Energy. Slippages in the construction of nuclear power plants have been and are expected to continue to be widespread. An evaluation of announced and projected slippages of nuclear capacity points to a growing divergence between nuclear energy requirements and supplies during the 1970-1975 period.

Based on the announcement of nuclear plant orders as representing requirements (or original anticipated availability), it is possible to derive an estimated requirement for nuclear energy. The projected plant completion dates, with anticipated slippages, provide a basis for

estimating potential supply. Since all the plants have been ordered that are expected to be operating by the end of 1975, such an approach provides a useful method for evaluating demand and supply.

Nuclear energy supplies and requirements for the seven air quality control regions are based on the announced capacity of the Corridor. The nuclear energy requirements for the seven AQCRs are believed to represent 75% of the total nuclear generation of the Corridor. Nuclear facilities are assumed to operate at an average load factor of 80% and energy from nuclear generation is set equivalent to 10,000 Btus per kilowatt hour. Based on these conditions, it is possible to state the nuclear requirement-supply situation as follows:

1970 Given the slippages that have already been announced, nuclear energy supplies of 55 trillion Btus fell short of requirements (125 trillion Btus) by 56% or 70 trillion Btus.

1972 Slippages in nuclear plant construction schedules are expected to be particularly acute. Estimated nuclear energy of 241 trillion Btus will fall short of requirements (366 trillion Btus) by 34% resulting in an energy gap of 125 trillion Btus.

1975 The more realistic plant construction schedules placed by utility executives for this year should substantially reduce the generation deficit -- percentage-wise. The 93 trillion Btu deficit in anticipated nuclear generation represents a gap of only 12% in supplies (745 trillion Btus) in comparison to requirements (838 trillion Btus).

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1970 - THE ENERGY/FUEL REQUIREMENTS - SUPPLY SITUATION FOR SEVEN AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

	ORIGINAL FUEL UNITS			BRITISH THERMAL UNITS 2/	
	Requirements	Supply	Difference	Requirements 10^{12} Btu	Supply 10^{12} Btu
Total Energy	NA*	NA	NA	5,244	5,235
Petroleum (10^6 Bbls.)					
Distillate					
0.30% Sulfur 1/	189	189	0	1,095	1,095
Residual Fuel Oil					
0.51-1.0%	86	86	0	524	524
More than 1% S	236	238	+2	1,467	1,480
Total Resid	322	324	+2	1,991	2,004
Natural Gas (10^9 CF)					
Pipeline	1,173	1,156	-17	1,173	1,156
LNG	0	0	0	0	0
Total	1,173	1,156	-17	1,173	1,156
Coal (10^3 Ton)					
Anthracite					
0.51-1.00% S	3,075	3,075	0	74	74
Bituminous					
0.51-1.0% S	10,860	13,000	+2,140	283	338
More than 1.0% S	19,625	20,000	+ 375	503	513
Total	30,485	33,000	+2,515	786	851
Nuclear Energy 1/ (10^3 MWH)	12,527	5,460	-7,067	125	55

1/ Sulfur content is shown by percentage weight classes. Since nuclear generation adds no sulfur to the environment and natural gas contributes only a small amount, energy from these sources could be considered part of the lowest sulfur content class.

2/ See Appendix II, Table 1 for conversion factors used for specific quality and types of fuels.

* NA - Not applicable.

Table 3

1972 - THE ENERGY/FUEL REQUIREMENTS - SUPPLY SITUATION FOR SEVEN AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

	ORIGINAL FUEL UNITS			BRITISH THERMAL UNITS[2]	
	Requirements	Supply	Difference	Requirements 10^{12} Btu	Supply 10^{12} Btu
Total Energy	NA*	NA	NA	5,706	5,886
Petroleum (10^6 Bbls.)					
Distillate 0.30% Sulfur[1]	193	193	0	1,119	1,119
Residual Fuel Oil					
0.30-0.50% S	216	106	-110	1,298	637
0.51-1.0%	174	191	+ 17	1,068	1,171
More than 1% S	0	136	+136	0	842
Total Resid	390	433	+ 43	2,366	2,650
Natural Gas (10^9 CF)					
Pipeline	1,318	1,263		1,318	1,263
LNG	--	10			10
Total	1,318	1,273	-45	1,318	1,273
Coal (10^3 Ton)					
Anthracite 0.50-0.70% S	1,200	1,200	0	29	29
Bituminous					
.51-1.0% S	19,550	17,150	-2,400	508	449
More than 1.0% S	0	5,000	+5,000	0	125
Total Bituminous	19,550	22,150	+2,600	508	574
Nuclear Energy[1] (10^3 MWH)	36,588	24,115	-12,473	366	241

1/ Sulfur content is shown by percentage weight classes. Since nuclear generation adds no sulfur to the environment and natural gas contributes only a small amount, energy from these sources could be considered part of the lowest sulfur content class.

2/ See Appendix II, Table I for conversion factors used for specific quality and types of fuels.

* NA - Not applicable.

Table 4

1975 - THE ENERGY/FUEL REQUIREMENTS - SUPPLY SITUATION FOR SEVEN AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

	ORIGINAL FUEL UNITS			BRITISH THERMAL UNITS 2/	
	Requirements	Supply	Difference	Requirements 10^{12} Btu	Supply 10^{12} Btu
Total Energy	NA*	NA	NA	6,876	7,531
Petroleum (10^6 Bbls.)					
Distillate 0.30% Sulfur 1/	219	219	0	1,269	1,269
Residual Fuel Oil					
0.30-0.50% S	275	240	-35	1,652	1,442
0.51-1.0%	172	207	+35	1,047	1,261
More than 1% S	0	100	+100	0	622
Total Resid	447	547	+100	2,699	3,325
Natural Gas (10^9 CF)					
Pipeline	1,570	1,441		1,570	1,441
LNG		30	--		30
Total	1,570	1,471	-99	1,570	1,471
Coal (10^3 Ton)					
Anthracite .51-1.0% S	1,000	1,000	0	24	24
Bituminous					
51-1.0% S	18,290	21,600	+3,310	476	569
More than 1.0% S	0	5,000	+5,000	0	128
Total Bituminous	18,290	26,600	+8,310	476	697
Nuclear Energy 1/ (10^3 MWH)	83,843	74,500	-9,343	838	745

1/ Sulfur content is shown by percentage weight classes. Since nuclear generation adds no sulfur to the environment and natural gas contributes only a small amount, energy from these sources could be considered part of the lowest sulfur content class.

2/ See Appendix II, Table 1, for conversion factors used for specific quality and types of fuels.

* NA - Not applicable.

It is assumed that the above deficiencies in nuclear electrical capacity to meet projected requirements during the 1970-1975 period will be made up by both the purchase of power outside the seven AQCRs and the development of additional fossil fuel electrical generating capacity within the seven AQCRs. Current estimates are that approximately 100 trillion Btus of additional generating capacity from fossil fuel power plants will be brought on line during 1972 with an additional 100 trillion Btu capacity available by 1975.

1.8 Conclusions. Although this Study addresses itself primarily to the seven air quality control regions of the Northeast Corridor, the conclusions and recommended actions that follow should be understood as applicable to the entire Northeast Corridor, as well as the Nation.

From the analysis of supply and requirements in the preceding section, fuel gaps were identified for the years 1970, 1972 and 1975. These gaps were summarized in Tables 2, 3 and 4. An analysis of these Tables by sulfur content of the respective fuels indicates certain energy quality differences between requirements and supply as shown by Table 5 below:

Table 5

Requirements & Supply of Energy by Sulfur Content Class (10^{12} Btus)

	1970		1972		1975	
Class (%S)	Requirements	Diff.*	Requirements	Diff.*	Requirements	Diff.*
.5% or less	2,393	-87	4,101	-831	5,329	-402
.51-1.0%	881	+55	1,605	+ 44	1,547	+307
More than 1.0%	1,970	+23	0	+967	0	+750
Total	5,244	- 9	5,886	+180	6,876	+645

* Difference between requirements and supply. Negative figures indicate deficiency in supply.

This Table shows that the critical area of concern is the .5% or less sulfur class which reflects energy quality gaps of 87 X 10^{12} Btus in 1970, 831 X 10^{12} Btus in 1972 and 402 X 10^{12} Btus in 1975. In all other sulfur classes the supplies of fuels to meet energy quality requirements are estimated to be ample in the three years examined.

The energy gap for the .5% or less sulfur class appears as shown below in units of equivalent fossil fuels.

Table 6

Energy Quality Gap Converted to Equivalent Units of Oil, Gas & Coal

	1970	1972	1975
Energy Gap (10^{12} Btus) (.5% or less sulfur)	87	831	402
Equals:			
Residual Oil (10^{6} Bbls.)	14	138	67
or:			
Gas (10^{9} cf)	87	831	402
or:			
Coal (10^{3} tons)	3,480	33,200	16,100

In relation to this energy quality gap, there are several possible measures that can be taken to eliminate or minimize this gap.

1. Increase Oil Imports. One way to increase these imports would be either to issue more "tickets" or remove quotas entirely on crude oils below < 0.5% S. The main foreign sources of low sulfur crude oil are Libya and Nigeria. Libya has

restricted production of crude oil below that capacity currently on line to conserve natural resources within the country. Nigeria, where most productive capacity was shut down because of the Civil War, is again producing without military restrictions. It is estimated that the two countries could produce an additional 500 million barrels and with a refinery residual yield of 25%, an additional 125 X 10^6 Bbls. of less than .5% S residual oil could be made available in 1972. Whether or not this total amount would reach the U. S., however, depends greatly on the international competition for this fuel. Another possible source of extremely low sulfur crude oil is the North Sea. Preliminary tests have shown that crude oil produced from these fields will contain about .18% sulfur content. It appears that the claims of the countries contiguous to the North Sea; primarily Britian, France, Denmark, etc., will take precedence over East Coast needs. However, when this production becomes commercially significant in 1974, it could provide approximately 110 X 10^6 barrels of low sulfur feedstock for domestic refineries and at an estimated residual fuel oil yield of 8% could provide 9 X 10^6 Bbls. of residual oil below $<$.5% S. If North Sea oil were used to produce topped crude, as much as 50 X 10^6 barrels of low sulfur topped crude might be available.

2. Increase Domestic Refinery Yields. A second possible solution to the energy quality gap in the years 1972 and 1975 would be a change in the refinery yield in the lower 48. Currently, domestic refineries tend to minimize the production of resid because of low resid prices and high gasoline prices. If hydro cracking and cat cracking facilities were shut down, the potential yield of residual oil could be as high as 25%. If current domestic refinery yields were increased this could supply an estimated 104 X 10^6 Bbls. of residual oil -- a significant part of which would be available to the seven AQCRs. This would help to minimize the impact of the energy quality gap in 1972 and 1975.

3. Topped Crude Oil. Currently, two power plants on the East Coast have utilized topped crude as boiler fuel. This requires modification of the burner system which could be made within a 90 day period. The use of topped crude is not recommended as an extensive or long term solution to any residual fuel oil shortage because the handling of topped crude presents certain safety problems and because the lighter factions of the topped crude, according to current regulations, must be used either as boiler fuel or re-exported.

4. Desulfurization Facilities. Another solution to solving the energy gap by the use of oil products would be to increase the residual oil desulfurization facilities within the U. S.

and the Caribbean. Currently, no additional desulfurization facilities have been announced to go on line past those scheduled for completion by 1972. It is recognized that not all projected production will be made available to the seven air quality control regions. By 1972, 273 MM barrels of desulfurized fuel oil products is expected. Of this, 106 MM barrels is forecast to be made available to the seven AQCRs. If this capacity could be doubled by 1975 the air quality fuel needs of the seven AQCRs in 1975 could be met with this additional capacity. The fuel quality needs of the seven AQCRs could also be met if more of the desulfurized fuel oil could be delivered to these markets. It is estimated that if requires from two to three years to bring a desulfurization facility on line from the time it was originally contracted for until it is in commercial operation.

5. Increase Natural Gas Availability. Estimated production of natural gas in the lower 48 during 1970 totaled $21,600 \times 10^9$ cf. Of this, the seven AQCRs received $1,156 \times 10^9$ cf. In 1972, the estimated production is $24,200 \times 10^9$ cf. If increased by 5%, by drawing down the domestic reserves at a rate faster than anticipated, the additional available natural gas of $1,200 \times 10^9$ cf, would more than meet the energy requirement of 831×10^9 cf

in 1972 for the seven AQCRs. If 27,400 X 10^9 cf estimated production in 1975 could be increased by a similar percentage, approximately 1,400 X 10^9 cf of additional natural gas could be available to meet the 402 X 10^9 cf natural gas equivalent energy gap. Naturally, not all of this increased gas would flow to the seven AQCRs, but this short-term solution could be utilized until either imports of LNG or coal gasification could be made available to meet future gas requirements.

6. LNG Imports. Another major fuel source to meet the energy gap of 1975 is liquefied natural gas (LNG). LNG requires large investment of capital for liquefication facilities at the source, cryogenic tankers to transport the gas which is maintained at a temperature of minus 260° F and docking facilities for 300,000 dead weight ton tankers at both loading and terminal points plus vaporization capacity and storage tanks near the consuming point plus pipelines constructed from these terminal points to these storage facilities. It is estimated that approximately three to five years are necessary to construct liquefication facilities, two years to construct cryogenic tankers and twelve to eighteen months for vaporization and storage handling facilities and three to five years for port facilities at port loading and terminal points. However, the potential LNG could be as high as 365 X 10^9 cf in the year 1975 if all these limiting parameters could be eliminated. This gas may

cost between 65¢ and 85¢ per M cubic feet when all costs are included in the price of the fuel delivered to the city gate. Currently, prices for pipeline natural gas in the Northeast Corridor range from about 40 to 70¢ per M cf.

7. Flue Gas Control Technology. By 1975, it is estimated that approximately 100 X 10^{12} Btus of generating capacity from fossil fuel power plants will be added to that on line in 1972. If this additional power plant capacity could utilize high sulfur fuels with flue gas control technology to control emissions to that level equivalent of burning low sulfur fuel it would help minimize the energy quality gap of 402 X 10^{12} Btus projected in 1975. This will require, however, that provisions be made now in the initial planning stages for these power plants to provide for the utilization of flue gas control technology by 1975. Techniques proven by 1973 could, in some instances, be added on to existing plants by 1975.

8. Coal Cleaning. Another possible development that could impact on the requirement and supply ratio of low sulfur coal is better coal preparation or coal cleaning. Recent studies conducted by the Bureau of Mines and other contractors for the Air Pollution Control Office indicate that the Appalachian area contains large potential supplies of coal that is amenable to washing to 1% S or below. It is estimated that approximately forty-six million tons of the current

production of Appalachia is cleanable to 1% S or below. If such a development could be encouraged, it would doubtless affect the demand for other low sulfur fuels since former users of coal would be offered the option of switching fuels if their fuel quality needs could be met by coal of this sulfur level. In other words, this action could possibly "free-up" other fuels such as natural gas and low sulfur residual oil which are in critical demand.

9. Low Sulfur Coal. Efforts are underway to locate additional resources of low sulfur coal. Some of this coal, located in the Appalachian area, will provide required quality fuel for the seven AQCRs. The low sulfur coal supplies in the west will help these regions only to the extent that other low sulfur fuel supplies are freed for use in the Northeast Corridor.

10. Long Range Actions. It should be recognized that certain longer term actions must also be taken in conjunction with the immediate action steps outlined in the next section to alleviate the crisis in clean fuel requirements to meet the environmental needs of the Nation. Some of these long-term actions include development of coal gasification technology, nuclear stimulation of some natural gas reserves, magneto-hydrodynamic systems (MHD), fuel cell and solar cell technology and the development of fast breeder reactors.

1.9 **Recommendations.** In the immediate future, there are several actions outlined below that can and should be considered to help amelorate the critical fuel crisis of meeting both energy and air quality needs.

1. Continue to emphasize the development and demonstration of flue gas control technology and ensure that this technology is applied to new electrical generating capacity during the period of 1972-1975 as well as stimulating its addition to old plants.
2. Increase the production of natural gas. Additional exploration and development drilling is needed to discover additional reserves and to bring them into production. Leasing of new areas will also help, although it should be noted that offshore wells must be adequately protected to avoid water pollution. More rapid rates of withdrawal of gas from formations will be needed to bring supplies to market, although such action would deplete reserves more rapidly. Increased utilization of domestic natural gas should be accompanied by firm policies and programs aimed at developing capabilities to produce gas from coal, oil shale, or other raw materials.
3. Provide economic incentives for the increased development of local and regional LNG storage facilities along with increased importation of LNG.

4. Increase the production of domestic residual fuel oil by adjustment of the yield in refineries; also, build and expand existing capacity of desulfurization facilities in both the Caribbean and within the continental United States. The incentive for such developments would be a higher price for low sulfur residual fuel oil.

5. Increase availability of low sulfur coal by washing to meet specifications below 1% sulfur content.

6. Economic incentives should be introduced to increase production of low sulfur fuels. Among such incentives might be reduction of royalties on Federal land leases, rebates for equipment purchases to meet clean air fuel requirements, transportation rate incentives for low sulfur fuels processed at the mine, higher gas well-head prices, bonuses for imports of low sulfur burning oil, and special loans for development of clean fuels.

7. The Jones Act [1/] should be reviewed by Congress to determine if the Act could be amended to require that cargo rates of domestic "bottoms" of interstate fuel shipments be no higher than international charter rates. Elimination of discriminatory marine shipping practices between domestic and foreign transporters would benefit the air quality objective of the Nation.

1/ An Act which requires that cargo between two U. S. ports be carried in U. S. flag ships.

Existing high rates for hauling Alaskan fuel in domestic "bottoms" has caused substantial quantities of LNG to be shipped to Japan at the expense of clean fuel requirements in the United States.

8. States could tax undeveloped mineable reserves held by coal companies, metal industries and others that hold low sulfur fuels so as to provide an incentive to develop such reserves rather than retaining them for appreciation potential. Such a program should be accompanied by State actions aimed at defining such available reserves. The program would be financed by the tax which should be set high enough to provide revenues to the States for other uses. Similarly, a Federal tax structure should be instituted to encourage the development of low sulfur fuel reserves on leased Federal lands.

9. Communication between Federal, State, local and private organizations concerned with air pollution needs must be improved and maintained. This would include fuel users and suppliers, air pollution control officials and other Federal Agencies such as the Office of Emergency Preparedness, the Federal Power Commission and the Department of Interior. As a first step, a program for the potential allocation of scarce low sulfur fuels could be developed in which priorities would be established to meet the

needs of critical air pollution areas. This can be accomplished under the authority given the President in the Defense Production Act of 1950.

10. A program to encourage more efficient use of fuels would also help the air quality. The use of waste heat from factories, from power plants and from incineration of solid waste materials could provide added useful energy without added pollution.

11. A Federal tax should be developed which will stimulate the private sector to both implement control techniques and develop greater supplies of low sulfur fuels. The tax should also stimulate private sector research, development and demonstration on and of methods for control of oxides of sulfur and improved efficiency of energy conversion.

APPENDIX I - SUPPLEMENTARY DETAILED ANALYSIS

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2.1 PURPOSE, SCOPE AND METHODOLOGY

2.11 Purpose and Scope. The purpose of this study is to provide an understanding of the energy/fuels situation as it affects the Northeast Corridor and to recognize environmental options that are implied. The study, therefore:

1. Examines energy requirements and supplies -- especially fossil fuels -- that will be needed to meet both energy needs and air quality requirements for stationary sources during the 1970-1975 period.
2. Identifies major energy and fuel quality gap areas.
3. Provides recommendations for filling these gaps in an environmentally acceptable manner.

The Northeast Corridor is defined to encompass the highly populated coastal area extending from Washington to Boston. As shown on the map (see Part 1, Page 4) it includes the seven air quality control regions (AQCRs) of: Boston, Providence, Hartford-Springfield, New York-New Jersey Metropolitan area, Philadelphia, Baltimore and Washington -- as well as the intervening areas between these regions. It is for these seven AQCRs that the study is designed to assess the availability of low sulfur fuels necessary to meet both energy and fuel quality requirements for stationary sources -- utility, commercial, residential, and industrial during the 1970-1975 period. Throughout the report, fuel "quality" refers to the sulfur content of fossil fuels.

2.12 Methodology. The organizational approach of the study represents several discrete, but related steps. First, projected stationary source energy requirements for the seven AQCRs have been

determined by energy type -- oil, gas, coal and nuclear -- and by fuel quality for the 1970-1975 period. Second, an examination was made of supplies potentially available to the AQCRs from both foreign and domestic sources. Third, a comparative evaluation was made of energy requirements and supplies to determine whether both energy and fuel quality needs can be met by specific fuels and nuclear energy. The nature and magnitude of energy and fuel quality gaps were evaluated with recommendations offered regarding specific steps needed for filling these gaps in an environmentally acceptable manner.

2.2 ENERGY/FUEL ANALYSIS

2.21 Energy/Fuel Requirements. Estimates developed by APCO's Division of Abatement and Division of Air Quality and Emission Data during the 1966-1969 period for seven standard metropolitan statistical areas (SMSAs) -- which eventually became the central cities for the AQCRs -- provided the data base for fossil fuel requirements. To compensate for subsequent growth in fuel use, as well as to compensate for the fact that the seven AQCRs eventually encompassed more area than represented by these earlier in-house SMSA figures, these estimates were increased by the Fuel Policy Section to approximate the current fuels situation. The original APCO studies were concerned only with combustion products (primarily SO_x and particulate emissions); little, if any, of the coal used in coke ovens was counted, so these estimates were consistent with the primary interest of this study -- the combustion markets. Certain

adjustments, primarily in the ratio of utility coal to oil burned, as well as trends in fuel consumption, were based on published consumption figures.[1/] Other adjustments were based on educated judgments. The area included in each of the seven air quality control regions are shown in Appendix II, Table 2.

The following assumptions were applied in updating the fuel use data for the seven AQCRs:

2.211 1970 fuel use derived from 1966-1969 data

1. Gas growth was estimated at 5% for New England - 10% for other areas.
2. In estimating volumes of distillate and residual oil, 40% of the total oil was estimated to be distillate and 60% residual. (Data received after the completion of the statistical analysis indicate these estimates are reasonably accurate.)

2.212 1972 requirement projected from 1970 projection

1. Yearly growth rate for gas was projected to 8% in New England, 10% in New York City and Philadelphia, and 15% in Baltimore and Washington.
2. In estimating volumes of distillate and residual oil, 35% of the total oil was assumed to be distillate and 65% residual.

1/ Sources used include publications at U. S. Bureau of Mines, Federal Power Commission, Atomic Energy Commission, National Coal Association, American Gas Association, American Petroleum Institute.

2.213 1975 requirements projected from 1972 projection

1. In estimating volumes of distillate and residual oil, 40% of the total oil was assumed to be distillate and 60% residual. All distillate was assumed to contain 0.30% sulfur.
2. In the New York City area the increased fuel use at the proposed addition to the Astoria power plant was split 75% low sulfur residual - 25% gas.

2.214 Requirements for Nuclear Energy. In contrast to the development of the fossil fuels requirements for each AQCR, estimates for nuclear energy requirements are based on announced orders for nuclear power plant capacity in the Corridor. Of the total generation from these plants, the seven AQCRs are expected to receive three-fourths of that energy during the 1970-1975 period. On the basis of this assumption, total requirements for nuclear energy is estimated in the nuclear section of this study (2.34) and summarized below:

Nuclear Energy Requirements in the Seven Air Quality Control Regions for Selected Years

10^{12} Btus	1970	1972	1975
	125	366	838

2.22 Fuel Quality Requirements. In estimating fuel requirements for 1970 by sulfur level, the regulations shown in Appendix II, Table 3

were utilized to determine breakouts of sulfur levels in each region. In additon, the following general assumptions of current conditions were made:

Anthracite - The tonnages assigned to the various regions involved are estimated, but are believed to approximate the existing demand in each area. All anthracite was presumed to have maximum sulfur content of 0.7%.

Bituminous - In assigning total coal tonnage to each region coal use was based on subjective estimates as well as on recent trends in consumption of coal in Corridor States. The sulfur content of coals was estimated on the basis of a 1967 Bureau of Mines survey that reported sulfur content classes of coal from operating mines.

Oil - All distillate was assumed to contain 0.3% sulfur.

In estimating fuel requirements for 1972 by sulfur level, the regulations shown in Appendix II, Table 3 were utilized to determine stringency of fuel quality and the following additional assumptions were made:

1. Boston - 2,700 MM gal. of residual is split in equal portions between 0.5% and 1.0% sulfur.
2. Hartford/Springfield - Assume 800,000 tons of bituminous coal is 1% maximum conforming to Connecticut law. Assume 1,040 MM gal. of residual is 1% sulfur maximum.

3. Providence - Assume 500,000 tons of bituminous coal is 1% maximum and 1,116 MM gal. residual is 1% maximum.

4. New York City - Assume 3,700,000 tons of bituminous coal was 1% maximum and 27 MM Bbls. of 1% sulfur residual oil was used in existing utilities. The balance of the residual oil was assumed to be 0.3 to .37% sulfur.

5. Philadelphia - Assume 3,700,000 tons of bituminous is 1% sulfur maximum. Assume residual oil is 50 - 50% split between 0.5 and 0.3% sulfur respectively.

6. Washington - Assume bituminous coal and residual oil are both 1% maximum.

7. Baltimore - Assume bituminous coal and residual oil are both 1% maximum.

In estimating fuel requirements for 1975 by sulfur level the most stringent regulations for the AQCRs were presumed to be in effect or a maximum level of 1% - whichever is less.

2.221 Fuel/Quality Requirements - Tables 4,5 and 6 in Appendix II present the estimated requirements for fuels for the years 1970, 1972 and 1975. The primary consideration of these Tables is that requirement for fossil fuels are determined by the sulfur regulations that pertain in the various AQCRs.

The sulfur levels that were assigned to the fuels, however, are believed to be a reasonable approximation of conditions.

2.23 Energy Quality Requirements. Based on the previous discussion of fuel and related quality requirements in the AQCRs and the requirements for nuclear energy for all the AQCRs, the following tabulation provides a summary of energy requirements -- in British Thermal Units and by fuel quality for 1970, 1972, and 1975. These requirements must be met by energy supplies of appropriate quality.

ENERGY/FUEL REQUIREMENT TYPE AND SULFUR CONTENT [1] CLASSES IN SEVEN AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR

	Demand in 10^{12} Btus.		
	1970	1972	1975
Total Energy Demand	5,244	5,706	6,876
Petroleum	3,086	3,485	3,969
Distillate Oil			
.3% Sulfur [1]	1,095	1,119	1,269
Residual Fuel Oil			
0.3-0.5% S	--	1,298	1,652
0.51-1.0% S	524	1,068	1,047
More than 1% S	1,467	--	--
Total Resid	1,991	2,366	2,700
Natural Gas [1]	1,173	1,318	1,570
Coal	860	537	500
Anthracite			
0.3-0.5% S	--	--	--
.51-1.0% S	74	29	24
Bituminous			
0.3-0.5% S	--	--	--
.51-1.0% S	283	508	476
More than 1%	503	0	0
Total Bituminous	786	508	476
Nuclear Energy	125	366	838

[1] Sulfur content is shown by percentage weight. Since nuclear generation adds no sulfur to the environment and natural gas contributes only an insignificant amount, energy from these sources could be considered part of the lowest sulfur content class.

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2.3 DETAILED ANALYSIS BY SOURCE OF ENERGY

Based on the estimates of energy and fuel requirements, it is possible to analyze the available supplies. Energy and fuel supply estimates are necessarily more uncertain than demand. Corridor supplies of appropriate quality residual fuel oil are highly dependent upon the international political and economic climate. AQCR fuel supplies are limited by available productive capacity, competing demands by other markets and labor difficulties. Moreover, the heterogeneity of air quality regulations throughout the AQCRs further adds to the complexity of the analysis. Nevertheless, even a gross evaluation of near-term trends in fuel quality requirements in comparison to fuel availability is revealing.

In this section, therefore, supply and requirements conditions of the specific fuels -- oil, gas, coal and nuclear energy -- have been summarized and analyzed. Further observations are made concerning the ability of supplies to meet requirements -- in total and by quality.

2.31 Residual Fuel Oil

2.311 Summary Statement. Residual fuel oil is basically the remainder left over after the refining process has removed the lighter, more profitable oils and gasolines from crude oil. At one time, the output of U. S. refineries was 23% residual fuel oil. However, millions of dollars have been invested in new refining processes to produce more of the higher

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priced petroleum products and less residual fuel oil so that now the production of residual fuel oil has been reduced on an average to about 6½% of the refinery output in the United States.

Imported residual fuel oil has improved its competitive position compared to coal and natural gas in utility boiler fuel market on the U. S East Coast. 1/ Its share grew from 14% in 1960 to 17% in 1965 and to nearly 30% in 1970 (estimated) and further increases are expected. Security of supply from both commercial and national security aspects will be one of the main limiting factors on further growth of this share.

Currently, 93% of the East Coast residual fuel oil supply is imported or is refined from imported crude oil. If present trends continue, it is anticipated that this proportion will increase. In discussing residual fuel oil as a utility fuel on the East Coast in 1970 or virtually anywhere in the U. S. in 1975 and beyond, we are discussing international oil.

The East Coast is a very heavily populated and highly industrialized region of the country. Therefore, the direct and indirect effects of the competition between oil and nuclear based power will have wide reprecussions on other regions and on other fuels. The main influence we anticipate is to push coal and natural gas (used as boiler fuel) back from the coastal regions toward their respective producing areas. This loss of market share may moderate somewhat the expected rapid increase in the price of natural gas and of coal.

1/ East Coast is defined as Petroleum Administration for Defense District 1; i.e., the States from Maine to Florida east of the Appalachian Mountains.

The international oil industry has amply demonstrated during the 1960s that it is capable of maintaining an extraordinarily rapid growth in spite of numerous political and economic upheavals.

The Free World oil industry, exclusive of the U. S., has maintained an astonishingly high growth rate. Production in 1959 was 9.6 million b/d which increased to 25.6 million b/d in 1969. The average compound growth rate for the decade is 10.3% per year. The 1970s are starting even stronger. In spite of civil war (as in Nigeria) pipeline shutdowns (as in the Middle East) politically inspired production curtailments (as in North Africa) and a worldwide tanker shortage -- crude production during the first eight months of 1970 increased by 12.2% over the corresponding period of last year.

The international oil industry has also demonstrated during the last decade that it can largely convert an entire continent, Europe, to light and heavy fuel oil, and that simultaneously, it can provide virtually the entire base of a large and rapidly expanding economy, Japan.

Overall sustained compound growth rates in the 8 - 15% per year range for fuel oils have been experienced in many countries in the past, without creating in themselves major price pressures. It is anticipated that these trends can continue unabated for the next ten years.

The magnitude of the world oil reserves, the rate of new discoveries, the spectacular tanker building program, the proliferation of

producing countries and of producing companies, the building of new offshore refineries are among the developments that support this line of reasoning.

2.312 Worldwide Crude Oil Reserves. The availability of low sulfur residual fuel oil is dependent ultimately on the worldwide availability of crude oil reserves. Table 7 (in Appendix II) summarizes the published proven reserves of the world in 1960 and 1970 and relates them to production. The reserves data is incomplete. This is, in large part, because of the lack of effort and technical expertise in the Nations possessing large quantities of reserves, as well as the natural reluctance of the oil companies to reveal company data prior to development of properties containing reserves. It is very likely that a rigorous worldwide application of exploration methods used in the United States would yield reserve estimates of at least 100 billion barrels more than are shown. A second limiting factor is the lag in reporting and compilation of these data. It is estimated that by 1970 worldwide reserves totaled about 611 billion barrels of crude. Table 7 shows only two billion barrels of North Sea reserves, but perhaps 5 - 10 billion may be developed by 1975. Nor does the Table show the twenty billion barrels of reserves which are proven on the North Slope of Alaska, and if counted would indicate nearly a 50% increase rather than a more than 10% drop for the total United States reserve situation. 1/

1/ In The Oil Import Question the Cabinet Task Force on Oil Import Control in February 1970 indicated reserves "of 40 billion barrels on the North Slope of Alaska would not surprise us." (P. 40)

The production data is more accurate. The resulting reserve to production ratios are moderately accurate, but as indicated, are on the conservative side. Accepting the conservative published data we find that Free World reserves, exclusive of the U. S. A. have increased from 235 to 474 billion barrels -- or by over 200 billion barrels. Production increased faster and consequently the reserves to production ratio dropped from 62 years to 47 years.

The main significance of this ratio is not that it has declined, but that it is still as much as three times higher than is necessary and most profitable for the industry. In other words, the current level of production could be appreciably increased without undue strain on the oil reservoirs, or on the statistical reserve position of the industry.

Total new discoveries have been somewhat restrained in recent years by the fact that in several Middle Eastern countries, which represent the most promising area, relatively little exploration is taking place as petroleum company efforts have been concentrated in other parts of the world. However, more than twice as much oil was discovered in Saudi Arabia in 1969 than was produced. New reserves of 2.7 billion barrels were added, offsetting production of 1.09 billion barrels. At the end of 1970, Saudi Arabian reserves were estimated at 128.5 billion barrels, making it the world's richest area in oil reserves.

Old producing areas are explored more intensively everywhere with unspectacular, but very significant "extensions, revisions and additions" to existing known oil fields.

Huge, previously virtually untouched territories, Alaska, Australia, much of Latin America, much of Africa, the Arctic and especially the shallow seas offshore all the continents are being intensively explored for the first time.

Very significant new finds were made in Alaska, in the North Sea and offshore Indonesia. The exact timing, location, and size of additional individual discoveries cannot be predicted, but is seems likely that continued exploratory effort will yield very significant results during the next decade and that there are sufficient worldwide reserves actually and potentially available to support all foreseeable growth of demand for all oil products for the next 10 years and beyond.

2.313 Worldwide Production of Crude Oil. The international oil crisis of 1970 is expected to affect the international oil trade for several years. During the 1970-1975 period, international oil demand is expected to increase at the rate of 7.5% per year. By mid-1973, conditions should be favorable for most countries to meet their requirements and begin replenishing their drawn-down stocks. The reasoning behind these observations are discussed below:

1. The Middle East. Although the six day war ended in June, 1967, a Middle East settlement has not yet been reached. The Arab-Israeli conflict is having a major impact on international oil supplies. The closing of the Suez Canal, the shutdown of the Trans Arabian Pipeline (Tapline) the discouragement of new production, and general uncertainties have made growing reliance on Middle East oil a contingent liability.

Although the Middle East supplied more than 28% of the world's total oil production in 1969, while increasing its production by 10% over the previous year, the increase in 1970 was only 9 %. The slower growth in Middle East oil production is a major contributor to the current oil crisis. As a result of the reopening of the Tapline at the end of January 1971, 480,000 b/d of crude from the oil fields of Saudi Arabia are flowing to the Mediterranean after a 270 day shutdown. This will particularly alleviate some of the supply problems of Western Europe. It will also relieve the pressure on tanker capacity and on the price of oil supplied to the European market. Saudi Arabian oil can be supplied to Western Europe 83¢ a barrel cheaper than by shipping around Africa. New prices set by oil exporting countries, however, will probably result in net increases in costs. It is assumed Middle East oil production will increase at a 10% per year rate (as it experienced in 1969) from now until 1975, but that eastern Europe will receive a larger share of Arabian production than it has received in the past. Nevertheless, most of the oil can be expected to reach the Free World Market.

2. Africa. In 1969, African production grew to 1.7 billion barrels representing an almost 29% increase from the previous year. Although Africa is a "late comer" relatively speaking in the oil game, production in 1969 represents some 12% of the

world's total. It is believed that a continued rapid expansion of African oil production can be expected.

Even with uncertainties related to Libya and Algeria concerning royalties and production, it is estimated that expansion of production in Nigeria and other North African countries resulted in 28% growth in African production in 1970. In the 1970s, continued increases in production are expected although the political situation in North Africa makes it seem probable that the growth pattern may be erratic because of political developments.

Nigeria has been producing oil since 1956, but production was interrupted by the Civil War except in offshore facilities belonging to Gulf, Mobil and Texaco-Chevron. Within the country, the biggest producer is a combine headed by Shell and British Petroleum which has resumed operations after the war. Total production reached more than one million b/d in 1970. By 1972 production may reach three million barrels per day. Africa can be expected to provide most of the Eastern Hemisphere's low sulfur crude to refineries supplying the Northeast Corridor with low sulfur residual fuel oil.

3. <u>The United States</u>. Although the United States produced almost one-fourth of the world's total oil supplies in 1969, it has consistently lost ground in percent of world production as new and more economic sources of oil have been found around the globe. While total world oil production increased by about 8% in 1969, and almost 9% in 1970, the growth in domestic production was only 1.3% in 1969 and about 4½% in 1970

(including both crude oil and natural gas liquids). Because of the international oil supply situation, domestic oil production (in the contiguous U. S.) is expected to increase by 3% during the 1970-1973 period. Higher levels of production will be made possible by increased allowables of currently productive wells, as well as new discoveries. It is expected that Alaskan crude will probably not be available before 1975 to the lower 48 so the reserve to production rates in the United States is expected to decline. The pipeline to Valdez and the Northwest Passage appear to be hopeful goals for the 1980s rather than effective supply in the 1970s. Also, a change in the Jones Act 1/ will be necessary to allow economical transport of oil from the Valdez terminal to the lower 48; otherwise, a large building program for the Merchant Marine and subsidies will be required.

4. Other North American Countries and Central America. One of the many benefits of the U. S. is to have a large country to the north -- Canada -- with bountiful resources compared to population and energy demands. A growing source of Free World energy resources will undoubtedly be Canada. Although Canada's share of world production represented only 3% of the total in 1969, production increased by over 10% in 1970 and production is expected to advance more rapidly during the 1970-1975 period.

1/ The Jones Act requires that oil moving from one U. S. port to any other U. S. port should be carried in U. S. flag tankers.

The United States is looking to Canada for help in the current fuel crisis and for long-term needs. Canada is the only immediately available significant supplementary source of added supplies of acceptable fossil fuels except for very limited amounts of relatively high cost liquefied natural gas imported by special tankers. The Canadian oil and gas industry appears eager to help supply the enormous demand of America for fuel -- if long-term contracts are assumed and the price is satisfactory to them.

Meetings have been taking place between officials of both countries. There is an attempt being made to forge a "continental energy policy" for North America. Over the long haul, the United States will probably need every barrel of oil and every cubic foot of gas Canada can spare.

5. Western Europe. Although on-shore Western Europe will stretch what production capability they currently have, it is not expected to reach a level of 200 million barrels per year during the 1971-1973 period. By the end of 1974, it is expected the North Sea will be supplying some of the needs of Western Europe. To the extent that North Sea oil replaces foreign oil in Europe, more low sulfur African oil may be available for U. S. markets.

6. South America. Although gains in South American production have lagged behind that of most areas in recent years, current

steps taken by the President to improve relationships with South America and plans to increase the tempo of oil exploration and development should permit a 5% per year increase in supplies from this area during the 1970-1975 period. With low sulfur fuels in high demand, supplies of this area have been neglected. Nevertheless, with worldwide supplies in tight supply and desulfurization plants planned for this area, demand for South American oils can be sufficient to support a 5% growth in supply.

7. Asia and Oceania. The area most likely to experience one of the fastest rates of growth is that of Indonesia and Southeast Asia. Although 1969 production of this area accounted for only 2% of the world's total, the 17.5% gain in 1969 production plus reported new finds of this area suggest that the 17.5% annual rate of increase is possible throughout the 1970-1975 period. Although supplies from this area will not find ready access to the Northeast Corridor, it will relieve some of the international pressure of world oil supplies and some oils of this area will enter U. S. markets on the west coast.

8. Sino-Soviet Bloc. Production of Russia now represents some 15% of the world total. Russia's rate of output growth in 1969 was 6.1% and in 1970 the eastern European production increased by about 5%. Russian oil needs (including some exports) may grow more rapidly than production and they may import some oil from the Arabian countries.

9. General Comments on International Oil Supplies. A little more than a decade ago, the world found itself in another oil crisis associated with the closing of the Suez Canal. As is the current case, prices of oils and tanker rates soared to new high. Under such circumstances pressures for oil price increases may be expected from the Middle East to Texas.

Oil sellers who feel they have been tied to certain customers under unfavorable agreements sometimes use shortage and tight supply situations to negotiate more favorable terms and this situation adds new uncertainty to already volatile situations such as exist in the Middle East and North Africa.

2.314 Foreign Crude Oil Reserves of Low Sulfur Oil - A Supply Availability Constraint. Almost 475 billion barrels of proved foreign crude oil reserves exist. Of the known reserves, some 13.6% have a sulfur content of .25% or less -- representing 61,8 billion barrels. It is noteworthy that almost two-thirds of these very low sulfur content reserves exist in Africa with slightly more than 40% of foreign reserves in this class located in Libya as shown in Table 8 in Appendix II. Also shown is the fact that only 17.3% foreign crude oil reserves contain 0.5% sulfur or less (representing 80.1 billion barrels) while less than 21% contain less than 1% (or 96.9 billion barrels).

Near-term reliance on foreign naturally occurring low sulfur oils calls for dependence on North African oils -- Libyan, Algerian, and Nigerian -- for meeting the fuel requirements of the Northeast Corridor

while desulfurization facilities are being built and expanded to reduce the sulfur content of oil.

2.315 Desulfurization Facilities to Meet Low Sulfur Fuel Needs - A Capacity Constraint. There are two basic methods for removing sulfur from residual fuel oil. The first is direct hydrodesulfurization of the residual fuel. The second method is vacumn gas-oil hydrodesulfurization. A problem in hydrodesulfurization treatment of high metal resids is that they foul the catalysts. This means that Venezuelian resid which is high in metals may be economically impossible to desulfurize to a low enough sulfur level. On the other hand, Arabian resid, also high in sulfur content, may be easier to desulfurize because of its lower metals content. Presently, the capacity on line for desulfurization of resid in the Caribbean amounts to approximately 453,500 barrels daily which will be increased to about 749,000 barrels daily by 1972. The details for each plant are shown in Table 9, Appendix II.

All these plants utilize the vacuum gas-oil hydro treaters to desulfurize resid. The American Independent Oil Company operating in Kuwait has a residual desulfurization plant with a capacity of 30,000 b/d. The Kuwait National Petroleum Company has a plant with a rated capacity of 28,000 b/d which can desulfurize resid. In the U. S., Humble Oil Company has a plant rated at 16,000 b/d and Cities Service Company has one rated at 2,500 b/d. American Oil Company has a plant under construction and Cities Service has another plant underway that will be capable of producing 3,500 b/d. There also is a possibility of obtaining some low sulfur resid from a plant located in Mexico operated by Pemex with a rated capacity of 18,500 b/d.

As critical as this problem of resid supply may be, refineries may be able to and probably will meet the 1.0% weight sulfur limit for the heating period 1970-71. By 1972, in many areas of the Northeast Corridor, plans are projected to lower the sulfur specifications to 0.3 to 0.5%. It is estimated that the total requirements for this quality fuel in the U. S. will not be met. Further requirements for low sulfur resid will probably have to be met by desulfurizing high sulfur oils. A study of the world's sulfur content of residual fuel oils indicates that availability of 2.5% weight sulfur is typical for the Eastern Hemisphere and 1.9% is typical for the Western Hemisphere. The Ekofish Oil Field in the North Sea has a sulfur content of only 0.18% weight sulfur and its metal content is very low. This low sulfur oil may be blended with the resid from both the Eastern Hemisphere and the Western Hemisphere to meet the sulfur requirements when the field begins to supply large quantities of oil. Most resid is the low gravity, high sulfur content and has high concentrations of vanadium and nickel. With a heavier Middle East resid, such as Khafji or Ratawi [1/] the vacuum gas-oil may reduce sulfur content by about 30 to 35%, but most requirements require at least a 75% sulfur reduction to produce fuel oils of less than 1% weight sulfur. There is a process by which the Esso Company removes 85 to 90% of the sulfur in resid. It is estimated that it will cost 40¢ a barrel for VGO desulfurization to reduce resid from 2.5% to 1% sulfur content. Hydro treating of 2.5 resid to the same level would cost about 55¢ per barrel. This cost, of course, depends on the cost of feed stock.

1/ Oil fields in the Kuwait - Saudi Arabia neutral zone.

2.316 Transportation as a Limiting Factor in Supplying Fuel Needs - The Tanker Shortage. Most of the Free World's oil reserves are located in the Middle East at great distances from the major markets in Europe, Japan and the United States. Transportation is, therefore, a major factor in the availability and cost of international oil.

Over short distances, crude oil moves by pipeline or barge. The Trans Arabian Pipeline from Saudi Arabia to Lebanese ports on the Mediterranean Sea was built to bypass the Suez Canal or a long trip around Africa, but the bulk of the world's oil moves a short distance to a port and then a much longer distance by tanker to the markets.

By mid-1970 the tanker fleet capacity reached 137.8 million tons, a net increase of 100 million tons over what was available 15 years ago. The carrying capacity of this fleet expressed in "T-2 tanker equivalents" 1/ increased even more due to the increased speed and efficiency of the newer ships. It grew from 2.1 to 9.5 thousand T-2 equivalents or by 330% -- a compound growth rate of 10.6% over 15 years.

Even more dramatic has been the growth in the size of the individual ships. In 1955, there were no tankers in the 50,000+ groups, but by 1966 one-third of the fleet was in this category. As recently as 1966, only 20 ships (2.7% of the carrying capacity) exceeded 100,000 tons, but by 1970 those groups grew tenfold to 223 ships and 27.1% of the carrying capacity. Statistics on the world tanker fleet are shown in Tables 10, 11 and 12 in Appendix II.

1/ T-2 tanker equivalents are a measure of oil carrying capacity of tankers reflecting the size and speed of the ships.

Finally, as recently as two years ago, there were only 17 tankers larger than 200,000 tons, or 3.4%, but by 1975 it is expected that more than 350 of these giants will account for more than 41.5% of the carrying capacity. The dominant ship size in the world fleet, which even today tends to be one of the 10 - 49,000 ton class (39.5% in 1970) is rapidly being replaced by those of the 200,000+ ton class (41.5+% in 1975). This expansion and upgrading of the World Tanker Fleet is currently just keeping up with increased worldwide demand for oil and is barely able to compensate for major interruptions such as the closure of the Suez Canal, the shut-down of the Trans Arabian Pipeline and reduced production in North Africa; in the future will provide for substantial growth. By the middle of the 1970s, this completely changed new tanker fleet will become a force in its own right in world oil markets. These huge new tankers, which will be available by the hundreds will seek continuous employment.

Estimates of cost reduction are uncertain at this stage because the first ships over 200,000 tons have only recently entered regular commercial service. Some serious questions have been raised concerning the cost of accommodating these giants in ports and concerning the cost of insuring them against pollution damages. It is estimated that, taking into account all costs and expense differentials on long voyages, the transportation costs per barrel for a 200,000 tonner is roughly one-third that of a 20,000 tonner.

On the basis of tankers in service and ordered, a compound growth rate of the fleet of 10% per year is assured for the next five years.

This growth may accelerate under the stimulus of high tanker rates to about 12% per year. In the latter case, the share of the giant tankers will be even higher than estimated.

In the absence of further major interruptions, the industry is expected to adjust fully to existing conditions by 1973. Should the interruptions be reversed; i.e., the Trans Arabian Pipeline or the Suez Canal be re-opened, the change would be very swift and quite dramatic in magnitude with a sharp drop in tanker rates and a slowdown in the building program.

2.317 Political Considerations in Oil Producing Countries - A Constraint on Production of Crude Oil. Threats by Mid East and North African Nations to cut off Western Hemisphere petroleum supplies and nationalize petroleum properties points out the vulnerability of the United States oil supplies to a very few Nations whose interests are often not the interests of the United States. The Middle East oil producing countries presently supply about 13% of our total crude imports. These are high sulfur crudes. The largest source of low sulfur crude, outside the continental United States, is in Libya. Crude oil production was cut back severely after the overthrow of King Idris in September of 1969. The nationalist government, comprised of military officers, restricted crude oil production by American companies. Amoseas owned by Texaco Inc. and Standard Oil of California was ordered to reduce production by 100,000 b/d from its output in early 1970 of 384,000 b/d. Occidental Petroleum, whose production in early 1970 was 800,000 b/d, was ordered by the Libyan

government to cut by 300,000 b/d. Also, because of a dispute about the price - tax structure for LNG, the Libyan government has refused to allow LNG to be shipped. As a result, the storage tanks at the new $168 million liquefaction plant at Marsa-el-Brega have filled up and the plant is flaring gas at the rate of 100 MM cfd.

The ten nation Organization of Petroleum Exporting Countries (OPEC), which includes the six Persian Gulf Nations, threatened to cut off most of the world's oil exports if they were dissatisfied with negotiations with representatives of the international oil companies.

The six countries of the Persian Gulf -- Iran, Saudi Arabia, Kuwait, Iraq, Qatar and Abu Dhabi, who produced 13 million barrels of oil daily in 1970 recently signed a five year agreement with the oil companies. The agreement provides for a 35¢ per barrel increase in Persian Gulf posted prices, a fixed tax on profits of 55%, 5¢ per barrel increases on June 1, 1971, and on January 1 of 1973, 1974 and 1975, plus a 2.5% increase on the same dates to compensate for world inflation and a system of gravity differentials that will increase the cost of heavier crudes.

The Shah of Iran has threatened Western Oil Companies with nationaliziation in the next decade. Iran might take over the refining of its oil when present contracts expire in 1979. Nigeria plans to take control of its oil industry within the next four years. It has established a national oil corporation to take effective control of the oil industry. It plans to take control through exploration, mining, refining, distribution and marketing activities.

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2.318 Supply Requirements for Residual Fuel Oil on the East Coast in 1970, 1972 and 1975. The Administration has taken seven steps to achieve a full fuel balance this winter. First, the import of natural gas liquids from Canada has been exempted from the Canadian crude oil quota limitation of 395,000 b/d in Districts 1-4 east of the Rockies. This will build to 40,000 b/d minimum. Second, the importation of liquid petroleum gas (LPG) from the Western Hemisphere will be permitted without present restrictions on products. It is estimated that this volume might build to 40,000 b/d. Third, the importation of #2 fuel oil will be increased in District 1 by requiring that licenses be used at the rate of 80,000 b/d in the first quarter of the year and eliminate historical import quotas early next year. Fourth, permit topping of imported crude oil to be used in District 1, provided that the light products are used by the plant for fuel and not sold in the fuels market. Fifth, allow topping of crude oil from Canada for use as fuel. Sixth, viscosity requirements will be relaxed for crude oil used for burning. This will allow a greater number of crude oils to be included in the definition of resid (which can be imported into District 1 for use as fuel). Seventh, permit the transportation of oil from Canada by waterway. And finally, in an order signed in December 1970 by the President, 250,000 barrels per day of crude and refined oil products were allowed into the United States, comprised of an additional 100,000 barrels of imported crude, plus another 150,000 barrels resulting from decontrol of previously restricted products. The decontrolled items include 40,000 b/d of No. 2 home heating oil from the East Coast and 60,000 to 70,000 b/d

of natural gas liquids. In addition, controls will be removed from ethane, butane and propane used as refinery feedstocks. In 1970, fuel oil needs were met on the East Coast by a combination of the steps taken by the Administration and the cooperative efforts by the fuel industry.

In 1972, the only expected problems are in relation to the fuel quality. It is estimated that there will be a shortfall in supply of approximately 110 MM barrels of residual fuel oil of a quality of .5% sulfur or less. Requirements for low sulfur fuels between .5% and 1% are not expected to present problems and it is anticipated that there will be a surplus of supply of high sulfur residual fuel oil.

In 1975, a fuel supply balance should be achieved as a result of the expansion of tanker fleet and desulfurization facilities. The seven air quality control regions on the East Coast are expected to require 322 MM barrels for consumption in 1970, 390 MM barrels in 1972, and by 1975, 447 MM barrels will be consumed in these markets.

The new refineries located on offshore islands or free trade zones and operated by companies not previously active in the international oil industry represents a major new development in the supply picture (for example, Bahamas Refinery Company in Freeport, Bahamas, and Amerada Hess in the Virgin Islands). These large new refineries rely on the simplest and lowest cost technology available. From a commercial standpoint, they can and do buy crude virtually anywhere in the world. Their original location was determined by considerations of serving the U. S. East Coast market. These refiners produce 50-60% residual fuel oil,

the highest proportion in the world. As such, they are a new and highly efficient mechanism for the conversion of the enormous world crude oil reserves to very large quantities of usable fuel. In sharp contrast to these world developments, the physical volume of residual fuel oil production in the United States has shown a declining tendency since before World War II. The proportions of residual oil to all oil products has declined sharply and in a growing number of U. S. refineries no residual oil at all is produced. Because of the high cost of crude and the existing investment in equipment, the domestic industry will probably not provide large new quantities of residual oil unless the long range outlook is for high prices for residual fuel oil compared to crude oil and to gasoline.

2.319. Conclusions. The needs for residual fuel oil in the seven AQCRs of the Northeast Corridor are expected to grow by about 10% per year through 1972 and about 5% per year from 1972 through 1975. Sharp changes in the fuel quality requirements are expected. In 1970, residual fuel oil with more than 1% sulfur was acceptable for about three quarters of the needs and in 1972 and 1975, all oil will be less than 1% sulfur.

Supplies of fuel oil, which were in tight supply in the latter part of 1970, are expected to be more readily available during the next few years, but quality constraints in the seven AQCRs will present problems. Limited supplies of low sulfur crude oil, limited desulfurization capacity for residual fuel oil and low yield of residual fuel oil from U. S. refineries processing low sulfur crude oil restrict supply while the

growing needs for low sulfur burning fuels in the Northeast Cooridor, in the rest of the United States, and in many foreign countries add to the demand. Premium prices for low sulfur residual fuel oil may provide an incentive for additional output.

The most readily available source of low sulfur residual fuel oil, particularly for the short run, is straight distillation of low sulfur crude oil. In the United States, the largest producer of low sulfur crude, only 6 1/2% of the refinery output is residual fuel oil. An increase in residual fuel oil production at U.S. refineries could help; an increase in the refinery yield of low sulfur residual of 1% would supply the area's needs, if all this oil could be delivered to the Northeast Corridor. An increase of 1 1/2% would provide sufficient low sulfur oil to replace the shortage of natural gas as well as providing the oil market with quality products.

This solution could require that the low sulfur oil would be processed to residual fuel oil at East Coast or Gulf Coast refineries and might cause minor problems in the supply of other products.

Another possible source for additional low sulfur fuels in the short run is the possibility that more of the output from new desulfurization facilities would reach the seven air quality control regions. East Coast and offshore and Caribbean processing plants are best situated to supply the East Coast markets but to the extent that the seven air quality control regions use more of this product, other area air quality problems may be accentuated.

A third possible source for additional low sulfur oil is from imports of residual fuel oil refined from low sulfur foreign crudes. Libya,

Algeria, Indonesia, and Nigeria are the largest sources for low sulfur crude oil and all but Indonesia are situated in a position to supply the East Coast. The political situation in Algeria and Libya make it seem unlikely that major increases in supplies may be expected from these sources in the near future. Most of Nigeria's oil goes to Europe. If Nigerian oil production can be expanded more rapidly than the needs of the European market, or if Europe gets more supplies from the North Sea or other sources, more low sulfur Nigerian oil can then be made available to refineries supplying U. S. markets, and some relief may come from this source.

Another alternative is for power plants to use low sulfur crude oil to generate electricity. Plants can be converted to burn crude oil, but because crude oil has a lower flash point than residual fuel oil additional investments are required in safety equipment in most plants and some plant modification would be required. Because of the differences in crude oil quality, a long-term supply of a specific crude oil would be necessary for such a fuel switch to be attractive. A topped crude (crude with the light volatile products removed) would be more appropriate; it would be more compatible with existing equipment and the higher valued gasoline and distillate fractions of the oil would be burned at the lower crude oil price.

Additional facilities to desulfurize residual fuel oil would help the supply. It is possible that more will be built than have been announced, but any additional equipment of this type probably would not be in use before 1974 or 1975.

To the extent that stack gas desulfurization equipment is installed and operating, this will make the use of high sulfur resid possible without causing pollution.

The possibilities for getting additional oil supplies to meet the air quality standards in the short run seem to exist if the oil industry makes

a strong effort to supply them. This would require financial incentives in the form of price bonuses for low sulfur oil and assurances that the price bonuses will be in force long enough to pay out the costs. Disruptions in the international oil industry could complicate the oil supply picture at any time.

2.32 Natural Gas

2.320 Summary Statement. It is projected that the period 1970-1975 inclusive will see a decrease in reserves available to pipeline natural gas companies to supply the Northeast Corridor from the southwest part of the United States. A decline in the reserve/production rate from 14 to 1 to 10 to 1 is projected. This decline in reserves will not be arrested during the period. Assuming that the present annual incremental growth of demand in the Northeast Corridor of about 6% continues at its present rate and that additions to pipeline supply do not correspondingly increase from discoveries in the lower 48 States, gas fuel demands in the Northeast Corridor and the seven AQCRs will not be met by the domestic natural gas industry. The only immediate supplementary source is liquified natural gas. Almost all of the increased imports from Canada go into the Midwest and far west and thus, will not supply the gas fuel gap in the Northeast Corridor. Canadian gas will, however, benefit the northeast to the extent that it reduces the requirements for gas from the southwest. Gasified coal, delivery of natural gas from the North Slope of Alaska, and nuclear stimulated gas supplies will not be available in commercially significant quantities to service the Northeast Corridor or the seven AQCRs within it during the period 1970-1975.

Based on projected demands and supplies of natural gas, a growing fuel gap from this low pollutant fuel source is foreseen for the 1970-1975 period. Because of its relatively low cost and cleanliness, natural gas demand has grown rapidly. For these same reasons and particularly due to its highly desirable air quality characteristics, demand from

the seven AQCRs for natural gas is expected to continue an annual growth rate of approximately 6% through 1975. At the same time, it is projected that gas supplies to the seven AQCRs will rise at a slower annual growth rate of 4½% per year during the 1970-1975 period. This rate is in contrast to the 5.9% per annum overall growth in supplies for the Northeast and Middle Atlantic States during the 1960-1968 period, and a nationwide growth in demand of 9% for 1969, of which the seven AQCRs are assumed to have shared proportionately in that growth. The projected gas supplies in the Northeast Corridor are shown in Table 13 of Appendix II.

Given the estimated annual figure of 1,570 10^9 cf requirements for 1975 of supplies of natural gas are expected to reach 1,471 10^9 cf by 1975 as shown in Table 4 in Section I. The development of the supply function is premised on information and assumptions herein enumerated.

2.321 Reserves and Reserve - Production Ratio. Five States -- Louisiana, Texas, New Mexico, Oklahoma, and Kansas represent 91% of the Nation's gas reserves of which Louisiana (41.3%) and Texas (28.4%) represent almost 70% of the Nation's total reserves as shown in Table 14 in Appendix II. It is from these two States that most, if not all, of the gas supplied to the Northeast Corridor is obtained. Total net reserves of natural gas dedicated to interstate pipelines declined by 7.2 trillion cubic feet in 1969 to 191.5 trillion cubic feet as shown in Table 15 in Appendix II. The reserve-to-production ratio stood at 14.6 years in 1968. In 1969, it declined to 13.3 years. It is projected by FPC that gas reserves during the 1970-1975 period may decline to reach a reserve to production ratio of 10 to 1 by 1975. (See Table 16 in Appendix II.)

2.322 Supply-Price Availability. In the short term, the supplies of gas are relatively inelastic. Because of the necessary lead time between exploratory drilling activity and delivery to pipelines, any significant results from the growth in exploration and development activities will be seen after 1975.

2.323 Prices -- Intrastate and Interstate

a. Although it is projected that total gas supplies of the Nation will grow at a rate of 6% per year during the period, substantial quantities of the new gas will go into intrastate markets. In Texas, quantities of new gas are being sold for substantially higher prices than offered by interstate pipeline under the jurisdiction of the FPC. It has been reported (by the Independent Natural Gas Association of America) that new intrastate gas purchases in Texas are going for as high as 30¢/M cf. Area prices for new committed interstate gas in 1970 are 28¢-32¢/M cf in the Appalachian area. This area supplied about 2% of the total U. S. requirements.

The ratio of interstate to intrastate gas has remained constant since 1963 with about two-thirds of the gas supply delivered to the interstate market. However, sales to intrastate markets have the added attractions of a shorter reserve life requirement, a shorter time interval between contract negotiations and delivery, and prices are not regulated.

b. Although the average wellhead price of natural gas has risen by approximately 1/4¢ per year during the past five years to 16.7¢/M cf, the assumptions related to the availability of gas to the Northeast Corridor include a projection that the wellhead price of gas will rise by 1½¢/year or more during the 1970-75 period. Prices of the gas delivered to markets in

the seven AQCRs will reflect any field price increases, but will be subject to FPC regulation. Gas price increases in the Northeast Corridor will not be a means of attracting a larger share of the Nation's gas to this area.

2.324 Recent Supply-Demand Changes. Because of the severely cold 1969-1970 winter, as well as the shifting away from dirty fuels to natural gas, the year 1969 saw a rapid rise in the demand for natural gas of 9% which compares with a much slower growth rate of 6% nationally during the 1964-1968 period. Assuming that the national production of natural gas increases at a rate of 6% per year during the 1970-1975 period, the reserves-to-production ratio is projected to decrease from 14.0 in 1969 to 10.4 in 1975.

2.325 Natural Gas Imports. Worldwide production of natural gas increased by 9% in 1968, and international movements of gas are becoming more important. U. S. imports of natural gas increased by more than 23% in 1969 over 1968 to a total of 800 billion cubic feet.

These foreign gas sources(mostly Canada) made possible a 9% increase in supplies to U. S. markets with only a 6.9% rise in U. S. production. It is anticipated that policy towards Canadian gas will continue to encourage a rapid rise in imports -- on the order of 200 billion cubic feet added per year -- which will relieve some of the pressure on declining U. S. gas reserves in the Midwest area of the United States. This will relieve some of the supply pressure on the Southwestern gas producing States and help the Northeast Corridor.

2.326 Liquid Natural Gas Imports. Liquified natural gas offers an opportunity to significantly increase supplies of low pollution fossil fuels to the Northeast Corridor. LNG can be stored and later introduced

into the gas system of retail gas utilities or can be gasified upon receipt and introduced directly into the system. Significant quantities of LNG will be introduced into the Eastern Seaboard. Recently, the Federal Power Commission received applications to import the equivalent in gaseous form of one billion cfd of gas from Algeria and 425 MM cfd from Venequela in liquified form. The LNG will be brought in through a terminal to be built on the Chesapeake Bay at Cove Point, Maryland by a subsidiary of Columbia Gas System, Inc. The cost of this low pollution fuel will be at least 10¢ above comparable wholesale pipeline prices. It is estimated that prices f.o.b. Algeria "liquified" will be 35¢ per mcf. Transportation costs are estimated to amount to 28.0¢ per mcf giving a landing price at Cove Point from Algeria of 63¢ per mcf.

The El Paso Natural Gas Company will purchase LNG from Sonatrach, a State agency of Algeria. El Paso filed for permission to import an additional 700 MM cfd (equivalent in gaseous form) and says it has agreements to sell this supply.

Columbia Gas System's subsidiary has also negotiated to purchase LNG from an affiliate of Standard Oil Company of New Jersey. These supplies would be obtained from Venezuela. The landed price of LNG is estimated to be 53.5¢ per MM Btu. This would be composed of 40.5¢ f.o.b. Venezuela and an estimated 13.0¢ shipping charge. There are escalation clauses in these contracts pegged to Labor Department indices of hourly wages and manufacturer production workers and steel mill product prices.

Terminal storage and facilities at Cove Point are expected to cost around 100 million dollars which would translate into 5.3¢ per MM Btu

for both sources of LNG; i.e., Algerian and Venezuelian. An additional cost of LNG is estimated to be 1.4¢ per MM Btu for pipeline transmission costs. This would give a total price of 60.2¢ for Venezuelian LNG and 65.2¢ MM Btu for Algerian LNG. The first regular deliveries from Algeria are expected in late 1974 or early 1975. The Venezuelian supply will come from fields with proven reserves of 10.3 trillion cu. ft.; Algerian reserves are estimated to total 141.0 trillion cu. ft.

LNG imports prior to 1975 will not affect the impact of rising consumption on the production reserves ratio of natural gas coming from the southwestern part of the U. S. Imports of LNG are estimated to reach over one billion cu. ft. in 1971, rising to almost 10 billion cu. ft. by 1972 and reaching a level of 30 billion cu. ft. during 1975. This is about 0.1% of U. S. production. The price of the imported gas will continue to rise to at least 65 to 75¢ mcf by 1975. Costs will increase due to the adjustment factors built into the contract with Venezuela where 20% of the price is subject to annual adjustment based on published Venezuelian Government indices to reflect changes in Venezuelian labor costs after 1973 and changes in U. S. wholesale prices for machinery and equipment after 1974. There are also fixed annual escalations of 0.2¢/MM Btu. Also, the seller might reflect price increases due to changes in costs of taxes, duties and other fees imposed by the Venezuelian Government. Further, the freight or tax rate is subject to adjustment.

2.327 Demand-Supply Analysis for Natural Gas. Because of the importance of gas in energy consumption in the U. S., it is important to examine gas demands in the various consumption sectors of this country. There are four main areas of natural gas demand--- residential, commercial, industrial and electric utilities.

In the past two years more natural gas was used than discovered. According to Commissioner Brooke of the Federal Power Commission, this "discovery deficit" aggregated nearly 18 trillion cubic feet. The reserves to production ratio for the total United States (including intrastate gas) fell sharply during 1969 to 13.3 compared with 14.6 during 1968 as proved reserves declined during 1969 by 8.2 trillion cu. ft. Reserves at the end of 1969 were about one trillion cu. ft. less than 1963.

As far as natural gas is concerned, the energy-supply demand unbalance has become much more complicated since gas emerged as the hope that can meet today's problems of both protecting and better utilizing the Nation's environment. In actions designed to stimulate increased gas exploration and development, the Commission lifted the existing moratorium on rate increase filings by southern Louisiana area producers. Second, the Federal Power Commission has proposed another rule which would exempt 4,600 U. S. natural gas producers that sell less than 10 billion cu. ft. annually. Third, the Commission has ordered "second round" investigation ceiling rates for the Permian Basin and has agreed to accept gas sales applications for consideration even when proposed rates exceed existing ceilings. Fourth, the Commission has stayed rate reductions, refunds, and certain other obligations previously prescribed for Southern Louisiana area producers.

As an illustration of the continued demand for gas, Con Edison's experience is illuminating. In seeking approval for a new and vitally needed generating facility at Astoria, the New York City power company was committed to make every reasonable effort to obtain pipeline and liquified natural gas for use in the Astoria plant and its other fossil generating units. There is no question but that the current anti-pollution measures and anticipated clean air regulations in city areas will have a long range effect to increase the requirements for natural gas. The full effect of these anti-pollution regulations has yet to be experienced. This escalated demand for natural gas will reflect the enforcement activity of the various jurisdictions. This shortage of natural gas to meet clean air requirements comes at a time when fuel hungry areas and industrialized northeast, particularly New Jersey, are faced with shortages which require more fuel and greater selectivity in the quality of fuel used.

2.328 Summary. Looking forward to the decade of the 1970s, the question is "How will all this relate to the customer and what does it hold in the future for the industry?" We believe that in the 1970s we will see (1) a reduction of the rate of growth in natural gas use that was experienced in the 1950s and 1960s, (2) a change in the supply mix of gas energy to include significant amounts of imported natural gas to augment the supplies of natural gas from the contiguous 48 States, (3) a change in the market mix with a shift toward higher value uses and away from lower value uses, (4) an increase in the average prices for new gas supplies and higher costs of capital, (5) and a continued strong demand for gas as an energy source because of its cleanliness, convenience and adaptability.

2.329 Conclusions. In a kind of vicious circle, gas price regulation has made it the preferred fuel for air pollution conversions, even where alternate fuels are available. Annual increments of demand are approximately 2½ times what they were about six years ago. At the same time as these demands were increasing, the low wellhead prices were not encouraging adequate domestic exploration and development of new gas fields.

As regulatory commissions need to use very possible inducement to stimulate exploration and development of gas reserves, including wellhead price incentives, there should be an improvement in the supply situation. In the meantime, requirements for gas will exceed available supply and market needs will not be met.

2.33 Coal.

2.331 Summary Statement. The national total supply of coal is expected to expand over the next five years at a rate of 4 to 5%/year, and we assume that the total supply of coal will approximately equal or exceed the total requirements in the seven AQCRs of the Northeast Corridor during the 1970-1975 period. This is believed to be reasonable in light of the many conversions from coal to the fluid fuels because of their lower air pollution potential.

In spite of the fact that no data exists that would permit conventional analysis of the relationships between supply and requirements that exist in this area by sulfur content of the fuel, an empirical method based on available data and large measures of judgment has been developed to estimate the supply and demand for low sulfur coal.

The following are the conclusions based on this analysis:

1970 The estimated requirements for 13,935,000 tons of 1% or less sulfur coal is expected to be met, but not without the possibility of some spot shortages.

1972 The projected requirements for 20,750,000 tons of 1% or less sulfur coal will not be met by the projected supply of 18,350,000 tons. There will be a shortfall of at least 2.4 million tons during 1972.

1975 There will be a slight decrease in requirements to approximately 19,290,000 tons. It is expected that supply will have continued to grow at a rate to more than match this demand.

2.332 Appalachian Coal Reserves. The coal fields of the U. S. are distributed as shown in the map of Figure 1 in Appendix II. The largest deposits of coal with less than 1% sulfur coal lies in the western coal field. The coal fields of the mid section of the country are predominantly high in sulfur. Only 1% of the U. S. total coal of less than 1% sulfur lies in the fields along the Indiana, Illinois border. About 8% of the low sulfur coal is in the Appalachian coal fields. It is this coal, being nearest the Northeast Corridor, which has the greatest potential for supplying the low sulfur coal requirements of the AQCRs and specific attention is directed to the Appalachian area in the study.

In 1967, the Bureau of Mines, under APCO sponsorship, surveyed the coal producing companies in Appalachia that produced in excess of

100,000 tons during that year. The recoverable reserves held by these companies are shown in Tables 17, 18 and 19 of Appendix II. Table 17 shows the reserves behind the mines in operation in 1967 by sulfur level. Reserves are also separated by assignment to the captive or commercial market. The category titled "unknown" is for reserves which were not reported in either category and consequently, their classification is unknown.

Table 18 contains a similar break-out, but for reserves behind new mines scheduled to be opened between 1967 and 1972.

Table 19 shows the reserves held by mining companies that have not yet been assigned for production. Three years is the earliest that these reserves could be expected to be put into production, whereas the reserves of the previous two Tables are more immediately available for an expanded production rate.

The low sulfur coal reserves in Appalachia are located in coal districts 1, 3, 7, 8 and 13 as shown in Table 20 which shows the distribution of coal reserves in these districts by sulfur levels. Thus, the reserves can be compared with the requirements for coal of specific quality.

The total of all the less than 1% sulfur reserves in the hands of the surveyed mining companies is approximately 21.6 billion tons; however, the U. S. Geological Survey (USGS) reports approximately 81.7 billion tons of ultimate reserves in this same area as shown in Table 17. Even when one discounts the Geological Survey figure by 50% to account for

mineable coal, it is obvious that much more low sulfur coal exists in Appalachia than is currently controlled by mining companies.

Consequently, there appears to be plenty of mineable reserves of less than 1% sulfur coal to meet both the energy demand and air quality requirements of the AQCRs in the Northeast Corridor for the next decade. The constraints on the availability of low sulfur coals, therefore, lie with the current productive capabilities and distribution.

2.333 National Coal Supply and Requirements. The bituminous coal supply has been falling behind coal use on a national basis since 1968 when 545 million tons were produced, but 554 million tons were consumed. In 1969, the gap widened when 547 million tons were produced to meet consumption of 571 million tons. The excess use has been met by depletion of inventories.

Labor unrest and the attendant work stoppages during the past two years were primarily responsible for the short-fall that occurred; however, car shortages also made a significant contribution to the overall supply problem.

The first six months of 1970 saw production reach a total of 286.2 million tons, but estimated use was 291.5 million tons. For the full year, production is estimated at 590 million tons, enabling the coal industry to supply all needs plus some replacing of stocks.

2.334 AQCR Coal Supply Assumptions. As was noted earlier, the coal industry has made strong efforts to keep up with current needs. The Corridor supply of low sulfur coal available this year, in 1972 and in 1975 is, however, difficult to estimate. Up-to-date consumption

figures for the AQCRs by sulfur content are not available. The Bureau of Mines does, however, publish a yearly tabulation of shipments of coal to each State, showing the originating mining district. Table 21 in Appendix II contains this information covering the Corridor States of the AQCRs. By exercising judgment and making several assumptions it is possible to arrive at a rough estimate of the total low sulfur coal (1% or less) supply to the seven AQCRs. The following is an outline of this process:

1. It is assumed that all the 1% or less sulfur coal used is produced in Districts 1, 7 and 8. (Any low sulfur coal originating in Districts 2 and 3 would normally be consumed west of the Appalachian Mountains because of freight rates favoring these areas.)
2. It is further assumed that all coal originating in Districts 7 and 8 that is delivered in the Corridor States is 1% sulfur or less, and that 10% of coal produced in District 1 is 1% or less.[1/]
3. The rated yearly coal consumption of all coke ovens in the AQCRs is approximately 9,700,000 tons, according to the 1970 Keystone Coal Industry Manual (McGraw Hill). It is assumed that all of this coal is 1% sulfur or less. Since most of the coal is captive and commands a higher price, it is presumed to be unavailable to the commercial and industrial market.

Estimate of total supply of 1% sulfur coal in the Northeast Corridor in 1969:

1/ Some coal over 1% is shipped from Districts 7 and 8 and is delivered to the east coast, but for purposes of these rough estimates, this inaccuracy is considered not significant.

District 8	-	12,695,000
District 7	-	5,349,000
10% of District 1	-	3,927,000
Total	-	21,971,000 tons

Estimate of 1969 Industrial/Commercial Supply of 1% Sulfur Coal was:

21,971,000 - 9,700,000 = 12,270,000 tons

2.3351 1970. The estimated 1970 requirement for low sulfur coal in the seven eastern air quality control regions is 10,860,000 tons. This figure is appreciably less than the estimated supply of 13,250,000 tons for use exclusive of coke oven requirements.

2.3352 1972. In order to assure a continued supply of 9,700,000 tons of metallurgical coal for east coast steel mills and at the same time meet the needs for additional 1% sulfur coal in the area, a total supply of 29,250,000 tons will be required in 1972, a net increase of 6,250,000 tons in two years or an increase of 13.5% per year. The coal industry on a national basis is struggling to maintain a 6% growth rate per year and it seems unlikely that such a 13.5% rate of growth in low sulfur coal production can be achieved by the industry in two years.

Our projections for the low sulfur coal supply of the East Coast Corridor during the next two years are based on the assumption that a more realistic growth rate is 8%/year. On this basis, the projected supply for 1972 will be approximately 26,825,000 tons, about 2.4 million tons less than the projected requirements of 29,250,000 tons.

2.2353 1975. By 1975, the supply shortfall is expected to be resolved by a combination of a slight reduction in total demand to about 28,000,000 million tons and a continuation of the previously indicated growth in supply of 8%/year.

2.34 Nuclear Energy

2.341 Summary Statement. Slippages in the construction of nuclear power plants have been and are expected to continue to be widespread. As a result, an evaluation of nuclear energy requirements and supplies points to a substantial gap between expectations and supplies realized during the 1970-1975 period.

2.342 Nuclear Capacity. Following more than a decade of research and development by the Atomic Energy Commission and private industry, commercially viable nuclear power plants began entering domestic markets in the late 1960s. In recognition of the burgeoning role of this new energy source, it is estimated that by 1980, some 136,000 megawatts 1/ of atomic plant capacity will be in operation across the Nation. The Northeast Corridor is anticipated to represent as much as one-fourth of the Nation's total nuclear capacity.

Although some delays are generally anticipated with regards to nuclear power plant construction schedules -- especially where a relatively new technology is involved -- the length of delays for completing nuclear facilities has substantially reduced capacity margins of Corridor utilities beyond expectations.

1/ Source: Joseph A. DeCarlo and Charles E. Shortt, Uranium Chapter, 1970 Mineral Facts and Problems, Bureau of Mines.

With the belated arrival of the 520 megawatt Oyster Creek Nuclear Power Plant in New Jersey, Corridor nuclear capacity rose to approximately 1,000 megawatts by year-end 1969. By year-end 1975, more than sixteen thousand megawatts of capacity are expected to be in operation as shown in Table 22 in Appendix II. This figure represents a sixteenfold increase over 1969.

If we assume that announcements of nuclear plant orders represent nuclear power needs it is possible to derive requirements for nuclear energy. The projected plant completion dates, with anticipated slippages, provides a basis for potential supply. Since all plants that are expected to be operating by the end of 1975 have been ordered, such an approach provides a useful method for evaluating supply and requirements.

2.343. Requirements for Nuclear Generation. In Table 23 in Appendix II, therefore, expected requirements for nuclear energy for the 1970-1975 period is shown. For purposes of this Table, it is assumed that Corridor utilities expected delays in the completion of nuclear plants on the average of six months over their originally announced completion dates. This slippage is designed to compensate for generally anticipated delays in construction schedules, as well as typical minor construction delays and start-up problems. Given an 80% average capacity factor, as well as information on the months and years in which plants were expected to begin operation, it is possible to calculate requirements for nuclear generation in the Northeast Corridor. With these assumptions, Corridor nuclear generation is anticipated to

rise from 6.9 million megawatt hours in 1969 to 111.8 million megawatt hours in 1975 as shown in Table 23.

2.344 Nuclear Generation Supply. In Table 24 currently anticipated start-up dates for nuclear plants are shown. These dates reflect current plant slippages in start-up dates as they are currently foreseen. For the 1970-1972 period, it is believed the announced dates still remain somewhat optimistic, but are accepted as shown. History has shown that it is not uncommon for utilities to wait until the last moment before announcing that it is physically impossible to meet construction deadlines. As a result, very few slippages have been announced for the 1973-1975 period. A general adjustment of supply to compensate for this latter period will be made under the next topic.

2.345 Nuclear Energy Gap. In comparing the nuclear generation requirement in Table 23 with the nuclear generation supplied in Table 24 it is possible to determine a gap between requirements and supply as shown in Table 25. Since it is believed that nuclear generation supplied is reascnably reflected for the 1969-1972 period, start-up dates for this period are accepted as currently announced. Given these considerations, the cumulative generation deficit for the 1969-1972 period results in an energy gap equivalent to 370 trillion Btus (based on 10,000 Btus per kilowatt hour). With further slippages for this period being possible, even this energy defecit is likely to be conservative.

In order to compensate for unannounced but probable slippages during the 1973-1975 period, it is assumed that the energy deficit for this period is equivalent to that of the 1969-1972 period. Even though plants ordered for this latter period were placed with a longer lead

time and, therefore, more realistically assessed, increased concern by environmentalists over thermal pollution, asthetics and nuclear radiation has already contributed to delays of a nature that may not have been entirely anticipated. Although it is impossible to develop an accurate estimate of how much additional nuclear generation deficiency might be expected to exist by the middle of the decade, it should be noted that the capacity expected to be in operation by 1975 is some 140% greater than year-end 1972. Thus, it is believed that a cumulative nuclear generation "gap" for the 1973-1975 period that is equal in size to that of the 1969-1972 period would not seem to be unrealistic to assume. As a result, the 1973-1975 data was adjusted to assume a uniform supply deficit among the three years -- 1973, 1974, and 1975 as shown in Table 25.

Based on this evaluation and assuming that the seven air quality control regions require 75% of the Corridor's nuclear generation, the results appear as follows: given the slippages that have already been announced for 1970, nuclear energy supplies of 55 trillion Btus will fall short of requirements (125 trillion Btus) by 56% or 70 trillion Btus. Slippages in nuclear plant construction by 1972 will mean that nuclear energy of 241 trillion Btus will fall short of requirements (366 trillion Btus) by 34% or resulting in an energy gap of 125 trillion Btus. By 1975, when a more realistic plant construction scheduling is foreseen, the energy deficit of 12% is reduced to 93 trillion Btus with supplies of 745 trillion Btus in comparison to demand of 838 trillion Btus. Associated with this growth, the requirements for nuclear energy will rise from 2% of Corridor stationary source energy in 1970 to approximately 12% by 1975.

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TABLE 1

FACTORS USED TO
CONVERT UNIT QUANTITIES OF FUEL TO
BTUs FOR - ENERGY PORTION OF STUDY

OIL		
Distillate		5.80 MM BTU/BBL = 138,095 BTU/Gal
Resid	.31 to 0.5% S	6.008 MM BTU/BBL = 143,048 BTU/Gal
	.05 to 1% S	6.09 MM BTU/BBL = 145,000 BTU/Gal
	More than 1%	6.219 MM BTU/BBL = 148,071 BTU/Gal
GAS ----------		1000 BTU/CF
COAL		
Anthracite	0.7 % S	24 MM BTU/Ton
Bituminous	0.5 - 0.7%	27 MM BTU/Ton
	1% Max	26 MM BTU/Ton
	1.6 Max	25 MM BTU/Ton
	1-2 %	25.5 MM BTU/Ton
	2-3 %	26.4 MM BTU/Ton

TABLE 2

AIR QUALITY CONTROL REGIONS IN THE NORTHEAST CORRIDOR

Metropolitan Boston Intrastate: Includes The SMSA's of, Boston, Brockton, Cities of Gloucester and Marlborough and Towns of Acton, Essex, Foxborough, Hudson, Ipswich, Maynard, Rockport and South-Borough

Metropolitan Providence Interstate: Includes The Entire State of Rhode Island, The parts of Massachusetts in the Providence-Pawtucket-Warwick, SMSA, The parts of Bristol and Plymouth Counties (Mass.) not in the Boston Area and the Towns of Bourne and Sandwich, Massachusetts

Hartford-New Haven-Springfield Interstate: Includes the SMSA's of Hartford, New Haven, Springfield-Chicopee-Holyoke, New Britain, Meriden and Waterbury, The counties of Hampden, Hampshire and Franklin, Mass., Hartford, New Haven and Middlesex Connecticut

New Jersey-New York-Connecticut Interstate: Includes the New York-Northeastern New Jersey Standard Consolidated Area and Fairfield County, Connecticut

Metropolitan Philadelphia Interstate: Includes The SMSA's of Philadelphia, Trenton, and the counties of Salem, N. J. and New Castle, Delaware.

Metropolitan Baltimore Intrastate: The Baltimore SMSA

National Capital Interstate: The Washington, D. C. - Maryland - Virginia SMSA

TABLE 3

STATE AND LOCAL SULFUR OXIDES CONTROL REGULATIONS OF THE CORRIDOR APPLICABLE TO FUEL COMBUSTION SOURCES
(As of February 1971)

State	Area	Effective Date	Maximum sulfur content of fuel*	
			COAL	OIL
Connecticut	Statewide	9/1/71	1.0%	1.0%
District of Columbia		7/1/69	1.0%	1.0%
Maryland	Western Area	7/1/70	1.0% a/	1.0%
	Central Area	7/1/70	1.0% b/	1.0%
	Baltimore Area	7/1/70	1.0%	1.0%
	Washington Area	7/1/69	1.0%	1.0%
	Southern Area	7/1/70	1.0% c/	1.0%
	Eastern Shore	7/1/70	1.0% c/	1.0%
Massachusetts	Metropolitan Boston Inner City	10/1/70	.55 lb $S/10^6$ Btu (0.7% S)	.55 lb $S/10^6$ Btu (1% S)
		10/1/71	.28 lb $S/10^6$ Btu (0.37% S)	.28 lb $S/10^6$ Btu (0.5% S)
	Outer City	10/1/70	1.22 lb $S/10^6$ Btu (1.5% S)	1.22 lb $S/10^6$ Btu (2.2% S)
		10/1/71	.55 lb $S/10^6$ Btu (0.7% S)	.55 lb $S/10^6$ Btu (1.0% S)

Table 3 Continued

State	Area	Effective Date	Maximum sulfur content of fuel* Coal	Oil
New Hampshire	Statewide	10/1/70	2.8 lb S/10^6 Btu f/ (3.6% S)	0.5% S (No. 2 oil)
	A. Existing sources	10/1/72	2.0 lb S/10^6 Btu g/ (2.6% S)	0.4% S (No. 2 oil)
		10/1/70		1.5% S (No. 4 & 5 oil)
		10/1/71		1.25% S (No. 4 & 5 oil)
		10/1/72		1.0% S (No. 4 & 5 oil)
		10/1/70		2.0% S (No. 6 oil)
		10/1/71		1.5% S (No. 6 oil)
		10/1/72		1.25% S (No. 6 oil)
		10/1/73		1.0% S (No. 6 oil)
	B. New Sources	10/1/70	1.5 lb S/10^6 Btu f/ (2.0% S) 1.0 lb S/10^6 Btu g/ (1.3% S)	
New Jersey	Statewide	5/6/68	1.0 % S (Bituminous)	0.3 % S (No. 2 oil)
		10/1/70		0.3 % S (No. 2 oil)
		10/1/71	0.2% S (Bituminous)	0.2 % S (No. 2 oil)
		5/6/68	0.7 % S (Anthracite)	0.7 % S (No. 4 oil)
		10/1/70		0.4 % S (No. 4 oil)
		10/1/71	0.2% S (Anthracite)	0.3 % S (No. 4 oil)
		5/1/68		1.0 % S (No. 5 & 6 oil)
		10/1/70		0.5 % S (No. 5 & 6 oil)
		10/1/71		0.3 % S (No. 5 & 6 oil)
New York State	Statewide	6/1/70	1.65 lb S/10^6 Btu (2.1% S)	1.65 lb S/10^6 Btu (3.0% S)
	New York City-Metropolitan Area (Nassau, Rockland, Westchester Counties and City of New York)	10/1/69	Purchased for use 1% S	1% S
		4/1/71	New construction, installed or modified, 0.2 lb S/10^6 Btu (0.26% S)	0.2 lb S/10^6 Btu (0.37% S)
		10/1/71	Purchased for use 0.2 lb S/10^6 Btu (0.26% S)	0.2 lb S/10^6 Btu (0.37% S)

Table 3 Continued

State	Area	Effective Date	Maximum sulfur content of fuel* Coal	Oil
New York State (Con'd)	Utilities			
	A. Bronx, Kings, N.Y. Co.	10/1/68	1% S	1% S
	B. New York City Metropolitan Area	10/1/69	1% S	1% S
New Yorkk City		1/20/67	2.2% S	2.2% S
		5/20/69	2.0% S	2.0% S
		5/20/71	1.0% S	1.0% S
Pennsylvania	Allegheny County	12/17/69	2.5 lb $SO_2/10^6$ Btu (1.7% S)	2.5 lb $SO_2/10^6$ Btu (2.3% S)
	Philadelphia	5/1/70	Bituminous: 2.0% S	0.3% S (No. 2 oil)
		7/1/71	1.0% S	0.3% S (No. 2 oil)
		10/1/72	0.3% S	0.2% S (No. 2 oil)
		5/1/70		0.7% S (No. 4 oil)
		5/1/70	Anthracite: 0.7% S	0.4% S (No. 4 oil)
		10/1/72	0.3% S	0.3% S (No. 4 oil)
		5/1/70		1.0% S (No. 5 & 6 oil)
		10/1/72		0.5% S (No. 5 & 6 oil)
		10/1/73		0.3% S (No. 5 & 6 oil)
Virginia	Falls Church	1/1/70		1.0% S
	Fairfax County	7/1/69		1.5% S
	Alexandria	7/1/69	1.0% S	1.0% S
	Arlington County	7/1/69		1.0% S

*Figures refer to maximum allowable amount or percentage of sulfur in fuel, by weight, except as follows: Where limitations are expressed as lb/$SO_2/10^6$ Btu (as in Allegheny County, Pennsylvania), they refer to allowable sulfur oxides emissions, by weight, per million Btu of heat value of the fuel. Limitations applicable to all fuel combustion sources except as indicated in footnotes.

a/ Only equipment with capacity greater than 100 x 10^6 Btu per hour

b/ Only equipment with capacity greater than 500 x 10^6 Btu per hour

c/ Only equipment with capacity less than 500 x 10^6 Btu per hour.

f/ Effective during alert periods.

g/ Maximum three-month average sulfur content

Table 4

1970 Requirements For Fossil Fuels In The Seven AQCRs

Region	% S	Petroleum (Gallons, Millions)				Natural Gas (MMM cf)	Coal (Tons, Thousands)				
		Distillate	Residual Fuel Oil				Anthracite		Bituminous		
		0.3% or Less	Total	0.51-1.0%	More than 1%	0.3% or Less	0.5-0.7%	Bit. Tot.	0.5-1.0%	1%-2%	2%-3%
Boston		1,630	2,769	498	2,271	87	250	570	120	400	50
Providence		240	409	--	409	32	250	1,190	840	300	50
Hartford-Springfield		600	1,022	--	1,022	54	225	1,305	180	1,000	125
New York-New Jersey		3,680	6,262	2,152	4,110	536	700	10,200	7,200	3,000	--
Philadelphia		1,040	1,769	679	1,090	230	950	6,400	1,200	4,000	1,200
Baltimore		360	613	170	443	98	300	5,080	480	4,000	600
Washington, D. C.		400	680	113	567	136	400	5,740	840	4,000	900
Total		7,950 or 189 MM Bbls.	13,524 or 322 MM Bbls.	3,612 or 86 MM Bbls.	9,912 or 236 MM Bbls.	1,173	3,075	30,485	10,860	16,700	2,925

Table 5

1972 Requirements For Fossil Fuels In The Seven AQCRs

REGION	%S	Petroleum (Gallons, Millions) Distillate 0.3 or Less	Residual Fuel Oil Total	Residual Fuel Oil 0.3 - 0.5	Residual Fuel Oil 051 - 1.0	Natural Gas MMMcf	Coal - Tons, Thousands Anthratice 0.5 - 0.7%	Coal - Tons, Thousands Bituminous 0.7 - 1.0%
Boston		1,453	2,911	1,524	1,387	98	200	150
Providence		601	1,147	--	1,147	37	200	500
Hartford-Springfield		560	1,069	--	1,069	61	200	800
New York-New Jersey		3,640	7,540	6,374	1,166	601	--	3,700
Philadelphia		1,120	2,243	1,174	1,069	258	300	3,700
Baltimore		350	668	--	668	110	200	4,800
Washington		420	802	--	802	153	100	5,900
Total		8,144	16,380	9,072	7,308	1,318	1,200	19,550
		or 193 MM Bbls.	or 390 MM Bbls.	or 216 MM Bbls.	or 174 MM Bbls.			

TABLE 6

1975 Requirements For Fossil Fuels In The Seven Air Quality Control Regions

REGION	% S	PETROLEUM (Gallons in Millions) Distillate 0.3% or Less	Residual Fuel Oil Total	Residual Fuel Oil 0.3 - 0.5%	Residual Fuel Oil 0.51 - 1.0%	Natural Gas MMM cf	COAL (Tons in Thousands) Anthracite 0.5 - 0.7%	COAL (Tons in Thousands) Bituminous 0.7 - 1.0%
Boston		1,649	3,174	1,518	1,656	114	120	160
Providence		686	1,380		1,380	43	180	560
Hartford-Springfield		642	1,286		1,286	72	160	1,100
New York-New Jersey		4,029	8,590	7,500	1,090	719	--	1,700
Philadelphia		1,300	2,535	2,535	---	306	200	2,700
Baltimore		411	824		824	132	225	6,650
Washington		494	988		988	184	115	5,420
Total		9,211	18,777	11,553	7,224	1,570	1,000	18,290

Table 7

World Crude Oil Reserves, Production And Reserve/Production Ratio

	1960			1970		
	Reserves* (Billion Barrels)	Production	R/P Ratio	Reserves* (Billion Barrels)	Production	R/P Ratio
Middle East	183.2	1.9	95	344.6	5.0	69
Africa-North	7.8	0.1	84	64.3	1.7	37
Africa-Other	0.3	-	26	10.5	0.4	24
Asia and Oceania	11.7	0.2	57	14.4	0.5	28
Western Europe	1.6	0.1	15	3.7	0.1	28
Latin America	25.1	1.4	18	26.1	1.9	14
Canada	5.0	0.2	26	10.7	0.5	23
Free World (Excl. U.S.A)	234.6	3.9	60	474.4	10.2	47
U.S.A.	31.6	2.6	12	37.0	3.5	11
Free World	266.2	6.5	41	511.4	13.6	38
Communist Bloc	32.9	1.2	27	100.0	2.8	36
World	299.1	7.7	39	611.4	16.4	37

(Totals may not add due to rounding)

*Year end reserves

Source: 1960 - Petroleum Facts and Figures (American Petroleum Institute)
1970 - Oil and Gas Journal 12/28/70

ESTIMATED PROVED FOREIGN CRUDE[1] OIL RESERVES BY COUNTRY AND SULFUR CONTENT CATEGORIES AS OF JANUARY 1, 1970
(Billions of Barrels)

	Sulfur Content by Weight Percent					Total	% of Total
	0.00-0.25	0.26-0.50	0.51-1.00	1.01-2.00	Greater than 2.00		
Canada	3.2	0.9	3.5	0.4	0.4	8.4	1.81
Latin America							
Argentina	1.0	1.5	1.0	0.5	-	4.0	0.86
Bolivia	0.2	0.1	-	-	-	0.3	0.06
Brazil	0.8	-	-	-	-	0.8	0.17
Chile	0.1	-	-	-	-	0.1	0.02
Colombia	-	-	0.9	0.1	-	1.0	0.22
Equador	-	-	0.5	-	-	0.5	0.12
Mexico	0.2	-	-	3.4	1.9	5.5	1.19
Peru	0.3	-	-	-	-	0.3	0.06
Trinidad	0.1	0.1	0.2	0.2	-	0.6	0.13
Venezuela	-	-	0.3	3.5	11.9	15.7	3.39
Subtotal	2.7	1.7	2.9	7.7	13.8	28.8	6.22
Africa							
Algeria	7.9	0.1	-	-	-	8.0	1.72
Libya	25.1	10.0	-	-	-	35.1	7.58
Tunisia	0.6	-	-	-	-	0.6	0.12
Nigeria	4.9	0.1	-	-	-	5.0	1.08
U.A.R. (Egypt)	-	1.0	1.5	1.6	0.4	4.5	0.97
Gabon	0.3	0.1	-	0.1	-	0.5	0.10
Anglo-Cabinda	1.2	-	-	-	-	1.2	0.25
Subtotal	40.0	11.3	1.5	1.7	0.4	54.9	11.86

Table 8

ESTIMATED PROVED FOREIGN CRUDE[1] OIL RESERVES BY COUNTRY AND SULFUR CONTENT CATEGORIES AS OF JANUARY 1, 1970

(Billions of Barrels)

	Sulfur Content by Weight Percent						
	0.00-0.25	0.26-.50	0.51-1.00	1.01-2.00	Greater than 2.00	Total	% of Total
Near East							
Saudi Arabia & Netural Zone	-	-	-	48.9	85.0	133.9	28.93
Kuwait	-	-	-	-	75.7	75.7	16.36
Iran	-	-	-	53.1	2.5	55.6	12.01
Iraq	-	-	-	19.2	14.0	33.2	7.17
Bahrain	-	-	-	0.3	-	0.3	0.06
Qatar	-	-	-	6.3	-	6.3	1.36
Trucial States	-	-	3.0	4.0	-	7.0	1.51
Muscat & Oman	-	-	-	2.0	-	2.0	0.43
Turkey	-	-	-	-	0.7	0.7	0.15
Syria	-	-	-	-	1.2	1.2	0.26
Subtotal	-	-	3.0	133.8	179.1	315.9	68.25
South Asia, Far East, Oceania							
Indonesia	9.0	0.1	-	-	-	9.1	1.96
Brunei-Malaysia	0.6	-	-	-	-	0.6	0.12
India	1.0	-	-	-	-	1.0	0.21
Australia	2.5	-	-	-	-	2.5	0.54
Subtotal	13.1	0.1	-	-	-	13.2	2.85
Western Europe	0.2	0.4	1.2	-	-	1.8	0.38
Eastern Eurpoe & U.S.S.R.							
U.S.S.R.	1.9	3.8	5.7	22.8	3.8	38.0	8.21
Rumania	0.7	0.1	-	-	-	0.8	0.17
Subtotal	2.6	3.9	5.7	22.8	3.8	38.8	8.38
Mainland China	-	-	-	1.0	-	1.0	0.21
Total	61.8	18.3	17.8	167.4	197.5	462.8	100.0*
Cumulative Total	61.8	80.1	97.9	265.3	462.8		
Cumulative Percent	13.3	17.3	21.1	57.3	100.0		

1 Excludes natural gas liquids reserves, where known *Sum of % may not equal total due to rounding

Source: Data in Bureau of Mines Report of Investigation 7059, Sulfur Content of crude oils of the Free World (1967) updated by Fuels Policy Section Staff APCO to reflect the latest expert opinion on reserves. Minor differences between these reserve estimates and those shown in Table 7 have not been reconciled.

TABLE 9

FUEL DESULFURIZATION FACILITIES

AND REFINERY CAPACITY FOR BLENDING TO MEET FUEL QUALITY

REQUIREMENT FOR THE 7 AQCR's

	Capacity b/d			1970	1971	1972
	1970 Operating	1971 Additions	1972 Additions	Production MM Bbls	Production MM Bbls	Production MM Bbls
Shell, Curacao	35,000			12.78	12.78	12.78
Hess, V.I.	125,000			45.63	45.63	45.63
Shell, Cardon	50,000			18.25	18.25	18.25
Creole, Amuay	100,000			9.13*	36.50	36.50
Bahama Oil	125,000			22.82*	45.63	45.63
Lago, Aruba	--	80,000		--	7.30**	29.20
Amerada Hess		60,000			5.48**	21.90
Bahama Oil			40,000			14.60
Texaco, Trinidad			90,000			32.85
Cities Service, U.S.A.	2,500			0.91	0.91	0.91
Humble Oil, U.S.A.	16,000			5.84	5.84	5.84
American Oil, U.S.A.			3,500			1.28
Cities Service, U.S.A.			3,500			1.28
Pemex, (Mexico)			18,500			6.75
Operating 1970	453,500			115.36		
Additions 1971		140,000				
Operating 1971		593,500			178.32	
Additions 1972			155,500			
Operating 1972			749,000			273.40

* In operation only part of 1970
** Assumed to be in operation during only 3 months of 1971

Source: Oil and Gas Journal

TABLE 10

GROWTH OF THE WORLD TANKER FLEET

	1955	1966	1968	1970	1975
10,000 - 49,000 DWT					
Number	2,199	2,398	2,264	2,182	1,960
Million DWT	37.4	60.0	56.8	55.8	53.0
T-2 Equiv.	2,096	4,021	3,796	3,750	3,600
% of Total	100.0%	66.4%	48.4%	39.5%	23.5%
50,000 - 99,000 DWT					
Number		396	601	644	670
Million DWT		26.2	41.2	44.7	48.0
T-2 Equiv.		1,864	2,925	3,175	3,400
% of Total		30.9%	37.2%	33.2%	22.2%
100,000 - 199,000 DWT					
Number		20	99	133	190+
Million DWT		2.4	12.4	17.3	27.0+
T-2 Equiv.		166	880	1,275	1,950+
% of Total		2.7%	11.2%	13.4%	12.7%+
200,000 & over DWT					
Number			17	90	350+
Million DWT			3.7	20.0	90.0+
T-2 Equiv			263	1,300	6,350+
% of Total			3.4%	13.7%	41.5%+
Total					
Number	2,199	2,814	2,981	3,049	3,170+
Million DWT	37.4	88.6	114.1	137.8	218.0+
T-2 Equiv	2,096	6,051	7,864	9,500+	15,300 - 17,000
% of Total	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 11

WORLD TANKER FLEET AT END 1969 BY FLAG AND OWNERSHIP[1]
(2,000 D. W. Tons and over)

Flag	Ownership: Oil Company	Private	Government	Other	Total 1969	Total 1968	Change 1969 over 1968	%	Share of total 1969
	MILLION TONS DEADWEIGHT								
Liberia	4.9	25.8	--	--	30.7	26.6	+4.1	15	23%
Norway	0.2	15.5	--	--	15.7	16.4	-0.7	-	12%
U. K.	13.6	4.7	0.3	0.2	18.8	15.4	+3.4	22	14%
Japan	2.2	11.5	--	--	13.7	11.4	+2.3	20	10%
U. S. A.	3.9	3.4	1.8	--	9.1	8.8	+0.3	3	7%
Panama	3.3	2.0	--	--	5.3	4.9	+0.4	8	4%
France	3.1	2.0	0.1	--	5.2	4.7	+0.5	10	4%
Greece	--	5.8	--	--	5.8	3.4	+2.4	71	4%
Other Western Europe	8.7	10.7	0.1	--	19.5	18.2	+1.3	7	14%
Other Western Hemisphere	2.5	0.3	0.3	--	3.1	2.7	+0.4	15	2%
U.S.S.R., East Europe & China	--	--	5.4	--	5.4	5.1	+0.3	6	4%
Other Eastern Hemisphere	0.6	2.2	0.1	--	2.9	1.9	+1.0	53	2%
Total	43.0	83.9	8.1	0.2	135.2	119.5	+15.7	13.1%	100%

[1]Excludes combined carriers.

Source: BP statistical Review of the World Oil Industry 1969, p. 14.

Table 12

EMPLOYMENT OF WORLD'S ACTIVE TANKER FLEET ON MAIN VOYAGES IN 1969[1]

Voyages to	Voyages From U.S.A.	Caribbean	Middle East	N. Africa	Others	Total
U.S.A	4%	3½%	3%	1%	2%	13½%
Canada	--	1½%	1%	--	--	2½%
Other Western Hemisphere	--	1 %	1%	--	½%	2½%
Western Europe, North and West Africa	--	3 %	40½%	7½%	4%	55%
East & South Africa, South Asia	--	--	2%	--	--	2%
Japan	--	--	16½%	--	1%	17½%
Other Eastern Hemisphere	--	--	5½%	½%	½%	6½%
Soviet Bloc	--	--	½%	--	--	½%
Total	4%	9 %	70%	9 %	8 %	100%

[1]Estimated Proportions

Source: BP Statistical Review of the World Oil Industry 1969, p. 14

TABLE 13

NATURAL GAS SUPPLY

	1968 [1] 10^9 CF	1969 [3] 10^9 CF	1970 [4] 10^9 CF	1971 [4] 10^9 CF
NORTHEAST CORRIDOR				
Conn.	53.2	57.9	60.5	63.2
Mass.	132.3	144.2	150.7	157.5
R. I.	20.7	22.6	23.6	24.7
N. J.	268.5	292.7	305.9	319.6
N. Y.	319.9 [2]	348.7	364.4	380.8
Penn.	430.8 [2]	469.6	490.7	512.8
Del.	24.0	26.1	27.3	28.5
Md. & D. C.	149.1	162.5	169.8	177.4
Total	1,398.5	1,524.3	1,592.9	1,664.5

1/ - Source: 1968 Minerals Yearbook, Natural Gas Chapter, 1968 Natural Gas Supply (unadjusted) T

2/ - 50% of N. Y. supplies and 40% of Penn. supplies assumed to be outside metropolitan area.

3/ - Estimated on the basis of a 9% U.S. growth in 1969 as reported by Bureau of Mines, Departme

4/ - Estimated 4% growth rate in supply based on information developed in personal conversation personal judgment.

TABLE 13

NATURAL GAS SUPPLY

69[3] 10^9 CF	1970[4] 10^9 CF	1971[4] 10^9 CF	1972[4] 10^9 CF	1973[4] 10^9 CF	1974[4] 10^9 CF	1975[4] 10^9 CF
57.9	60.5	63.2	66.1	69.1	72.2	75.4
144.2	150.7	157.5	164.6	172.0	179.8	187.9
22.6	23.6	24.7	25.8	27.0	28.2	29.5
292.7	305.9	319.6	334.0	349.0	364.7	381.1
348.7	364.4	380.8	397.9	415.8	434.5	454.1
469.6	490.7	512.8	535.9	560.1	585.3	611.6
26.1	27.3	28.5	29.8	31.1	32.5	34.0
162.5	169.8	177.4	185.4	193.8	202.5	211.6
,524.3	1,592.9	1,664.5	1,739.5	1,817.9	1,899.7	1,985.2

ter, 1968 Natural Gas Supply (unadjusted) Table 3, pp. 733-4.

assumed to be outside metropolitan area.

69 as reported by Bureau of Mines, Department of Interior.

ormation developed in personal conversations with Federal Power personnel and

TABLE 14

DEDICATED* GAS RESERVES, PRODUCTION AND PURCHASES
FOR FIVE STATE AREA
1969

(Billions of Cubic Feet at 14.73 Psia @ 60°F.)

State	Year End Reserves	Percent of Total	Produced and purchased	Percent of Total
Louisiana	76,167.0	39.8	5,641.8	41.3
Texas	52,000.2	27.2	3,879.5	28.4
New Mexico	18,146.1	9.5	908.1	6.6
Oklahoma	14,251.4	7.4	1,140.2	8.3
Kansas	13,381.9	7.0	725.1	5.3
Total	173,946.6	90.9	12,294.7	89.9
Total all States - 191,455.9			13,676.8	

*Dedicated to Interstate Gas Companies

SOURCE: FPC News 7/2/70

TABLE 15

1968 - 1969 DOMESTIC RESERVES*, PRODUCTION AND PURCHASE
PIPELINE COMPANIES REPORTING ON FORM 15 AND FORM 15-A

(Trillions of Cubic Feet at 14.73 Psia @ 60°F.)

All Companies

	1968	1969	Increase (+) or Decrease (-)
Number of Companies	64	65	
Gas Reserves at Year End			
Company Owned	21.7	18.6	(-) 3.1
Independent Producer Contracts	177.0	172.9	(-) 4.1
Total	198.7	191.5	(-) 7.2
Annual Production and Purchases			
Company Owned	1.1	1.0	(-) 0.1
Independent Producer Contracts	11.7	12.7	(+) 1.0
Total	12.8	13.7	(+) 0.9

*Reserves Dedicated to Interstate Gas Companies

SOURCE: FPC News 7/2/70

TABLE 16

ANNUAL U.S. NATURAL GAS PRODUCTION AND RESERVES
(Billion Mcf @ 14.73 Psia & 60° Fahrenheit)

YEAR	PRODUCTION	YEAR-END RESERVES	RESERVE TO PRODUCTION RATIO
1964	15.3	279.4	18.2
1965	16.2	284.5	17.5
1966	17.5	286.4	16.4
1967	18.4	289.3	15.8
1968	19.3	282.1	14.6
1969	21.2	275.1	13.0
1970	21.6	282.0	13.0
1971	22.9	282.3	12.3
1972	24.2	282.7	11.7
1973	25.6	283.2	11.1
1974	26.5	284.3	10.7
1975	27.4	286.0	10.4

SOURCE: AGA, Actual 1964-69, FPC projections 1970-75.

TABLE 17

COAL RESERVES OF MINES OPERAT

IN 1967

MILLION OF TONS

STATE	COMMERCIAL				CAPTIVE			
	Sulfur Content				Sulfur Content			
	< 1%	> 1%	N.R.*	TOTAL	< 1%	> 1%	N.R.*	TOTAL
ALABAMA	94.00	24.04	-	118.04	117.50	144.30	-	261.80
EAST KENTUCKY	641.04	362.92	-	1,003.96	139.69	23.04	0.63	163.36
MARYLAND	-	3.75	-	3.75	-	-	-	-
OHIO	-	909.71	-	909.71	-	43.19	-	43.19
PENNSYLVANIA (Bituminous)	105.55	1,204.30	11.80	1,321.65	-	873.07	-	873.07
TENNESSEE	15.48	7.04	1.50	24.02	-	-	-	-
VIRGINIA	724.06	105.54	0.30	829.90	9.00	-	-	9.00
WEST VIRGINIA	1,702.17	1,240.72	5.64	3,957.53	907.30	1,133.46	-	2,040.76
TOTALS	3,282.30	4,867.02	19.24	8,168.56	1,173.49	2,217.06	0.63	3,391.18

*Not Reported

SOURCE: Bureau of Mines - 1967 Data

107 -107A

TABLE 17

ESERVES OF MINES OPERATING

IN 1967

MILLION OF TONS

AL	CAPTIVE				UNKNOWN		TOTAL			
	Sulfur Content				Sulfur Content		Sulfur Content			
	<1%	>1%	N.R.*	TOTAL	>1%	TOTAL	<1%	>1%	N.R.*	TOTAL
.04	117.50	144.30	-	261.80	-	-	211.40	168.34	-	379.84
.96	139.69	23.04	0.63	163.36	-	-	780.73	385.96	0.63	1,167.32
.75	-	-	-	-	-	-	-	3.75	-	3.75
.71	-	43.19	-	43.19	84.15	84.15	-	1,037.05	-	1,037.05
.65	-	873.07	-	873.07	-	-	105.55	2,077.37	11.80	2,194.72
.02	-	-	-	-	-	-	15.48	7.04	1.50	24.02
.90	9.00	-	-	9.00	-	-	733.06	105.54	0.30	838.90
.53	907.30	1,133.46	-	2,040.76	-	-	1,609.47	3,383.18	5.64	5,998.29
.56	1,173.49	2,217.06	0.63	3,391.18	84.15	84.15	4,455.79	7,168.23	19.87	11,643.89

107 .1074

TABLE 18

COAL RESERVES OF MINES
SCHEDULED TO BE OPENED 1967-19

MILLION OF TONS

	COMMERCIAL				CAPTIVE			U
	Sulfur Content				Sulfur Content			Su
	< 1%	> 1%	N.R.*	TOTAL	< 1%	> 1%	TOTAL	1%
ALABAMA	-	4.40	-	4.40	-	-	-	-
EAST KENTUCKY	97.04	255.22	10.00	362.26	43.70	-	43.70	2.60
MARYLAND	-	-	-	-	-	-	-	-
OHIO	-	208.96	-	208.96	-	34.70	34.70	-
PENNSYLVANIA (Bituminous)	0.52	341.24	381.41	723.17	-	-	-	-
TENNESSEE	93.47	-	3.30	96.77	-	-	-	-
VIRGINIA	363.62	0.52	-	364.14	9.00	-	9.00	-
WEST VIRGINIA	1,273.73	953.74	276.86	2,504.33	222.59	11.24	233.83	91.20
TOTAL	1,828.38	1,764.08	671.57	4,264.03	275.29	45.94	321.23	93.80

*Not Reported

SOURCE: Bureau of Mines - 1967 Data

108 - 108A

TABLE 18

COAL RESERVES OF MINES

EDULED TO BE OPENED 1967-1972

MILLION OF TONS

TAL	CAPTIVE			UNKNOWN			TOTAL			
	Sulfur Content			Sulfur Content			Sulfur Content			
	< 1%	>1%	TOTAL	1%	>1%	TOTAL	< 1%	>1%	N.R.*	TOTAL
40	-	-	-	-	-	-	-	4.40	-	4.40
26	43.70	-	43.70	2.60	-	2.60	143.34	255.22	10.00	408.56
	-	-	-	-	-	-	-	-	-	-
96	-	34.70	34.70	-	-	-	-	243.66	-	243.66
17	-	-	-	-	0.70	0.70	0.52	341.94	381.41	723.87
77	-	-	-	-	-	-	93.47	-	3.30	96.77
14	9.00	-	9.00	-	-	-	372.62	0.52	-	373.14
33	222.59	11.24	233.83	91.20	-	91.20	1,587.52	964.98	276.86	2,829.36
93	275.29	45.94	321.23	93.80	0.70	94.50	2,197.47	1,810.72	671.57	4,679.76

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TABLE 19

COAL RESERVES NOT YET ASSIGNED FOR PRODUCTION

MILLION OF TONS

STATE	UNKNOWN Sulfur Content				
	≤1%	>1%	N.R.,*	TOTAL	≤1
ALABAMA	1052.06	774.53	15.51	1842.10	1052.
EAST KENTUCKY	603.02	403.89	14.29	1021.20	603.
MARYLAND	-	5.00	72.20	77.20	-
OHIO	-	1504.57	-	1504.57	-
PENNSYLVANIA (Bituminous)	26.80	2636.79	18.25	2681.84	26.
TENNESSEE	30.00	100.00	-	130.00	30.
VIRGINIA	721.15	33.96	104.97	860.08	721.
WEST VIRGINIA	3209.93	4719.40	169.13	8098.46	3209.
TOTALS	5642.96	10178.14	394.35	16215.45	5642.

*Not Reported

Source: Bureau of Mines - 1967 Data

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TABLE 19

L RESERVES NOT YET

IGNED FOR PRODUCTION

MILLION OF TONS

NOWN Content			TOTAL Sulfur Content			
N.R.*	TOTAL		<1%	>1%	N.R.*	TOTAL
15.51	1842.10		1052.06	774.53	15.51	1842.10
14.29	1021.20		603.02	403.89	14.29	1021.20
72.20	77.20		-	5.00	72.20	77.20
-	1504.57		-	1504.57	-	1504.57
18.25	2681.84		26.80	2636.79	18.25	2681.84
-	130.00		30.00	100.00	-	130.00
104.97	860.08		721.15	33.96	104.97	860.08
169.13	8098.46		3209.93	4719.40	169.13	8098.46
394.35	16215.45		5642.96	10178.14	394.35	16215.45

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TABLE 20

RESERVES OF COMMERCIAL AND CAPTIV

AND UNASSIGNED RESOURCES

SOURCE: BUREAU OF MINES - 1967 DATA

Coal District	Sulfur Level	Commercial Reserves: Reserves of Operating Mines	Commercial Reserves: Reserves of Newly Scheduled Mines	Captive Reserves: Reserves of Operating Mines	Captive Reserves: Reserves of Newly Sche Mines
1	Unreported	11.80	381.41	--	--
	.1 - .7	3.85		--	--
	.7 - 1.0	101.70	.21	--	--
	1.7	74.05	1.21	13.00	--
	1.7	803.92	336.36	167.27	--
3	Unreported	--	236.84	--	--
	.1 - .7	--	--	--	--
	.7 - 1.0	119.64	13.22	--	--
	1.7	.58	2.93	14.20	--
	1.7	1,593.80	516.14	3.00	--
7	Unreported	--	40.02	--	--
	.1 - .7	491.42	741.42	462.58	225.00
	.7 - 1.0	153.80	375.97	3.84	--
	1.7	51.75	--	--	--
	1.7	16.47	--	--	--
8	Unreported	7.44	13.30	.63	--
	.1 - .7	856.46	123.98	310.28	.70
	.7 - 1.0	1,378.93	556.27	279.29	49.59
	1.7	557.24	97.86	23.04	11.24
	1.7	118.53	364.27	9.00	--
13	Unreported	19.24	671.57	.63	--
	.1 - .7	1,372.98	882.40	821.36	225.70
	.7 - 1.0	1,909.32	945.98	352.13	49.59
	1.7	810.63	103.05	457.04	11.24
	1.7	4,056.39	1,661.03	760.57	34.70
Total 5 Districts	Unreported	38.48	1,343.14	1.26	--
	.1 -.7	2,724.71	1,747.80	594.22	451.40
	.7 - 1.0	3,735.39	1,891.65	635.26	99.18
	1.7	1,494.25	205.10	507.28	22.48
	1.7	6,588.11	2,877.30	939.84	34.70

TABLE 20

COMMERCIAL AND CAPTIVE MINES

UNASSIGNED RESOURCES

SOURCE: BUREAU OF MINES - 1967 DATA

Captive Reserves		Unassigned Resources	
Reserves of Operating Mines	Reserves of Newly Scheduled Mines	Reserves of Newly Scheduled Mines	Reserves of Mining Companies Unassigned
--	--	--	158.39
--	--	--	.19
--	--	--	26.61
13.00	--	--	77.70
167.27	--	--	643.01
--	--	--	--
--	--	--	119.75
--	--	--	51.75
14.20	--	--	--
3.00	--	--	3,389.86
--	--	--	16.70
462.58	225.90	--	--
3.84	--	--	--
--	--	--	--
--	--	--	--
.63	--	--	117.87
310.28	.70	--	916.57
279.29	49.59	93.80	2,783.92
23.04	11.24	--	469.74
9.00	--	--	553.27
.63	--	--	394.35
821.36	225.70	--	2,561.41
352.13	49.59	93.80	3,081.55
457.04	11.24	--	1,424.82
760.57	34.70	.70	8,753.32
1.26	--	--	687.31
594.22	451.40	--	3,597.92
635.26	99.18	187.60	5,943.83
507.28	22.48	--	1,972.26
939.84	34.70	.70	13,339.46

TABLE 21

ORIGIN OF COAL USED IN THE NORTHEAST CORRIDOR - 1969

State of Delivery	Total 1000 tons	District of Origin 1	2	3 and 6	4	7	8
Maine New Hampshire Vermont Rhode Island	1,139	33	24	1,071	-	9	2
Massachusetts	2,225	962	3	152	-	83	1,025
Connecticut	2,295	2,125	-	87	-	27	56
New York	24,324	9,178	3,108	7,177	443	266	4,152
New Jersey	5,500	841	3	3,638	5	329	684
Pennsylvania	59,661	19,479	22,013	10,783	224	3,746	3,416
Delaward & Maryland	15,008	6,178	136	5,187	-	622	2,885
District of Columbia	1,230	478	-	10	-	267	475
Total	111,382	39,274	25,287	28,105	672	5,349	12,695

NOTE: Based on Bureau of Mines data, 1969 is a poor year to judge total productive capability because there were a number of strikes that affected shipments from all mining districts

TABLE 22

Announced, Estimated and Actual Operating Dates for Nuclear Power Plants in the Northeast Corridor 1969-1975

Plant Name	Operating Year	Initially Announced Operating Date	Actual or Expected Operating Date	Slippages in Megawatts	Actual and Expected Operating Capacity in Megawatts
1. Oyster Creek #1	1969	10/67	12/69		530
2. Millstone #1		8/69	11/70	652	
3. Indian Point #2		6/69	5/71	873	
Year End Total Capacity in MW					1000
4. Vermont Yankee	1970	10/70	10/71	514	
5. Milestone #1		8/69	12/70	652	828
6. Indian Point #2		6/69	5/71	873	
Year End Total Capacity in MW					1828
7. Indian Point #2	1971	6/69	5/71		873
8. Pilgrim Station		10/71	10/71		654
9. Vermont Yankee		10/70	10/71		514
10. Salem #1		12/71	12/72	1050	
11. 3 Mile Island #1		5/71	7/72	810	
12. Peach Bottom #2		3/71	5/72	1065	
13. Indian Point #3		6/71	5/73	965	
Year End Total Capacity in MW					3869
14. Peach Bottom #2	1972	3/71	5/72		1065
15. 3 Mile Island #1		5/71	7/72		810
16. Salem #1		12/71	12/72		1050
17. Indian Point #3		6/71	5/73	965	
Year End Total Capacity in MW					6794
18. Calvert Cliffs #1	1973	1/73	1/73		800
19. Indian Point #3		6/71	5/73		965
20. Fitzpatrick		4/73	5/73		821
21. Peach Bottom #3		3/73	3/73		1065
22. 3 Mile Island #2		5/74	12/73		810
23. Salem #2		5/73	7/73		
24. Shorham		5/73	5/75	819	
Year End Total Capacity in MW					11255
25. Milestone #2	1974	4/74	4/74		828
26. Calvert Cliffs #2		1/74	1/74		800
27. 3 Mile Island #2		5/74	12/73		810
28. Shorman		5/73	5/75	819	
Year End Total Capacity in MW					13693
29. Shorham	1975	5/73	5/75		819
30. Newbold Island #1		3/75	3/75		1088
31. Limerick #1		3/75	3/75		1065
Year End Total Capacity in MW					16665

TABLE 23

Demand for Nuclear Energy Based on Expected[1] Generation from Corridor Nuclear Power Plants

1969-1975

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Plant Name	Initially Announced Operating Dates plus 6 mos.[1]	Capacity in Megawatts	MWH of Generation of Pre-year Plants[2]		MWH of Generation from New Unit[3]		Total Generation in KWH x 10^3
Other Pre-69 Corridor Capacity	--	470	--				
1. Oyster Creek #1	4/68	530	--				
2. Indian Point #2	12/69	873					
Year End Total Capacity - 1969		1,873	6,912,000	+	0	=	6,912,000
3. Milestone #1	2/70	652	--		3,755,520		
Year End Total Capacity - 1970		2,525	12,946,176	+	3,755,520	=	16,701,696
4. Vermont Yankee	4/71	514	--		2,368,512		
5. 3 Mile Island #1	11/71	810	--		466,560		
6. Peach Bottom #2	9/71	1,065	--		1,840,320		
7. Indian Point #3	12/71	965	--		0		
8. Pilgrim Station	10/71	654	--		753,408		
Year End Total Capacity - 1971		6,533	17,452,800	+	5,428,880	=	22,881,680
9. Salem #1	6/72	1,050	--		3,628,800		
Year End Total Capacity - 1972		7,583	45,156,096	+	3,628,800	=	48,784,896
10. Calvert Cliffs #1	1/73	800	--		5,068,800		
11. Fitzpatrick	5/73	821	--		3,310,272		
12. Peach Bottom #3	3/73	1,065	--		5,520,960		
13. Shorham	11/73	819	--		471,744		
14. 3 Mile Island #2	12/73	810	--		0		
15. Salem #2	7/73	1,050	--		3,024,000		
Year End Total Capacity - 1973		12,948	52,413,696	+	17,395,776	=	69,509,472

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TABLE 23

Demand for Nuclear Energy Based on Expected[1] Generation from Corridor Nuclear Power Plants

1969-1975

Plant Name	Initially Announced Operating Dates plus 6 mos.[1]	Capacity in Megawatts	MWH of Generation of Pre-year Plants[2]		MWH of Generation from New Units[3]		Total Generation in KWH x 10^3
16. Milestone #2	4/74	828	--		3,815,424		
17. Calvert Cliffs #2	1/74	800	--		5,068,800		
Year End Total Capacity - 1974		14,576	89,496,576	+	8,884,224	=	98,380,800
18. Newbold Island #1	3/75	1,088	--		5,640,192		
19. Limerock #1	3/75	1,065	--		5,520,960		
Year End Total Capacity - 1975		16,729	100,749,312	+	11,041,920	=	111,791,232

1/ Because minor delays in full plant operation are common -- due to some brief slippages in construction schedules, resolution of some plant start-up problems, etc. -- it is assumed that utilities anticipated delays in plant operations on an average of six months. For that reason, six months have been added to initially announced operating dates as representing dates when plants were expected to reach full power operation.

2/ Generation from pre-year plants represent generation by capacity existing at the end of the previous year. All such plants are presumed to operate at an average capacity factor of 80 percent during 24 hours per day, 30 days per month, 12 months for the current year. Thus MWH = (.80x30x24x12) (Mw).

3/ Megawatt hours of generation from new units represents the generation from each new unit at an average 80% capacity factor times the number of hours per day x days per month x the number of generating months per year x capacity of each unit. Thus, MHW = (.80x30x24xMo.) (Mw).

TABLE 24

Supply of Corridor Nuclear Generation Based on Reported and Projected Operating Dates

1969-1975

Plant Name	Actual or Estimated Operating Date 1/	Capacity in Megawatts	MWH of Generation of Pre-year Plants 2/		MWH of Generation from New Unit 3/		Total Generation in KWH x 10^3
Other Pre-69 Corridor	--	470					
1. Oyster Creek #1	12/69	530	--		0		
Year End Total Capacity - 1969		1,000	2,436,480	+	0	=	2,436,480
2. Milestone #1	11/70	652	--		375,552		
Year End Total Capacity - 1970		1,652	6,912,000	+	375,552	=	7,287,552
3. Indian Point #2	5/71	873	--		3,519,936		
4. Vermont Yankee	10/71	514	--		592,128		
5. Pilgrim Station	10/71	654	--		753,408		
Year End Total Capacity - 1971		3,693	11,418,624	+	4,865,472	=	16,284,096
6. 3 Mile Island #1	7/72	810	--		2,332,800		
7. Peach Bottom #2	5/72	1,065	--		4,294,080		
8. Salem #1	12/72	1,050	--		0		
Year End Total Capacity - 1972		6,618	25,526,016	+	6,626,880	=	32,152,896
9. Indian Point #3	5/73	965	--		3,890,880		
10. Calvert Cliffs #1	1/73	800	--		5,068,800		
11. Fitzpatrick	5/73	821	--		3,310,272		
12. Peach Bottom #3	3/73	1,065	--		5,520,960		
13. 3 Mile Island #2	12/73	810	--		0		
14. Salem #2	7/73	1,050	--		3,024,000		
Year End Total Capacity - 1973		12,129	45,743,616	+	20,814,912	=	66,558,528

TABLE 24

Supply of Corridor Nuclear Generation Based on Reported and Projected Operating Dates

1969-1975

Plant Name	Actual or Estimated Operating Date [1]	Capacity in Megawatts	MWH of Generation of Pre-year Plants [2]		MWH of Generation from New Units [3]		Total Generation in KWH x 10^3
15. Milestone #2	4/74	828	--		3,815,424		
16. Calvert Cliffs #2	1/74	800	--		5,068,800		
Year End Total Capacity		13,757	83,835,648	+	8,884,224	=	92,719,872
17. Shorham	5/75	819	--		3,302,208		
18. Newbold Island #1	3/75	1,088	--		5,640,192		
19. Limerock #1	3/75	1,065	--		5,520,960		
Year End Total Capacity - 1974		16,729	95,088384	+	14,463,360	=	109,551,744

1/ Actual operating date represents the month and year in which full power plant operation was announced by the utility. Estimated operating date is the expected date of operation by utilities as they are currently projected. Both actual and estimated operating dates may and do represent slippages from the initially announced operating date. Additional slippages may occur which have not been announced.

2/ Generation from pre-year plants represent generation by capacity existing at the end of the previous year. All such plants are presumed to operate at an average capacity factor of 80 percent during 24 hours per day, 30 days per month, 12 months for the current year. Thus MWH=(.80x30x24x12)(Mw).

3/ Megawatt hours of generation from new units represents the generation from each new unit at an average 80% capacity factor times the number of hours per day x days per month x the number of generating months per year x capacity of each unit. Thus, MHW=(.80x30x24xMo.)(Mw).

TABLE 25

NORTHEAST CORRIDOR DEMAND, SUPPLY AND GAP IN NUCLEAR GENERATION AND ENERGY FOR THE 1969-1975 PERIOD

YEAR	ANNUAL GENERATION IN 10^6 KWH			1/	10^{12} BTUs OF ENERGY EQUIVALENT		
	DEMAND	SUPPLY	SUPPLY (ADJ.)		DEMAND	SUPPLY (ADJ)	GAP
1969	6,912	2,436	2,436		69.12	24.36	44.76
1970	16,701	7,287	7,287		167.02	72.87	94.15
1971	22,882	16,284	16,284		228.82	162.84	65.98
1972	48,785	32,152	32,152		487.85	321.52	166.33
1973	69,509	66,558	57,400		698.09	574.00	124.09
1974	98,380	92,720	85,972		983.81	859.72	124.09
1975	111,791	109,552	99,382		1,117.91	993.82	124.09

1/ Nuclear generation for 1973-1975 adjusted downward to make the generation deficit equivalent to the 1969-1972 period. The deficit is distributed uniformly among the three years -- 1973,1974 and 1975.

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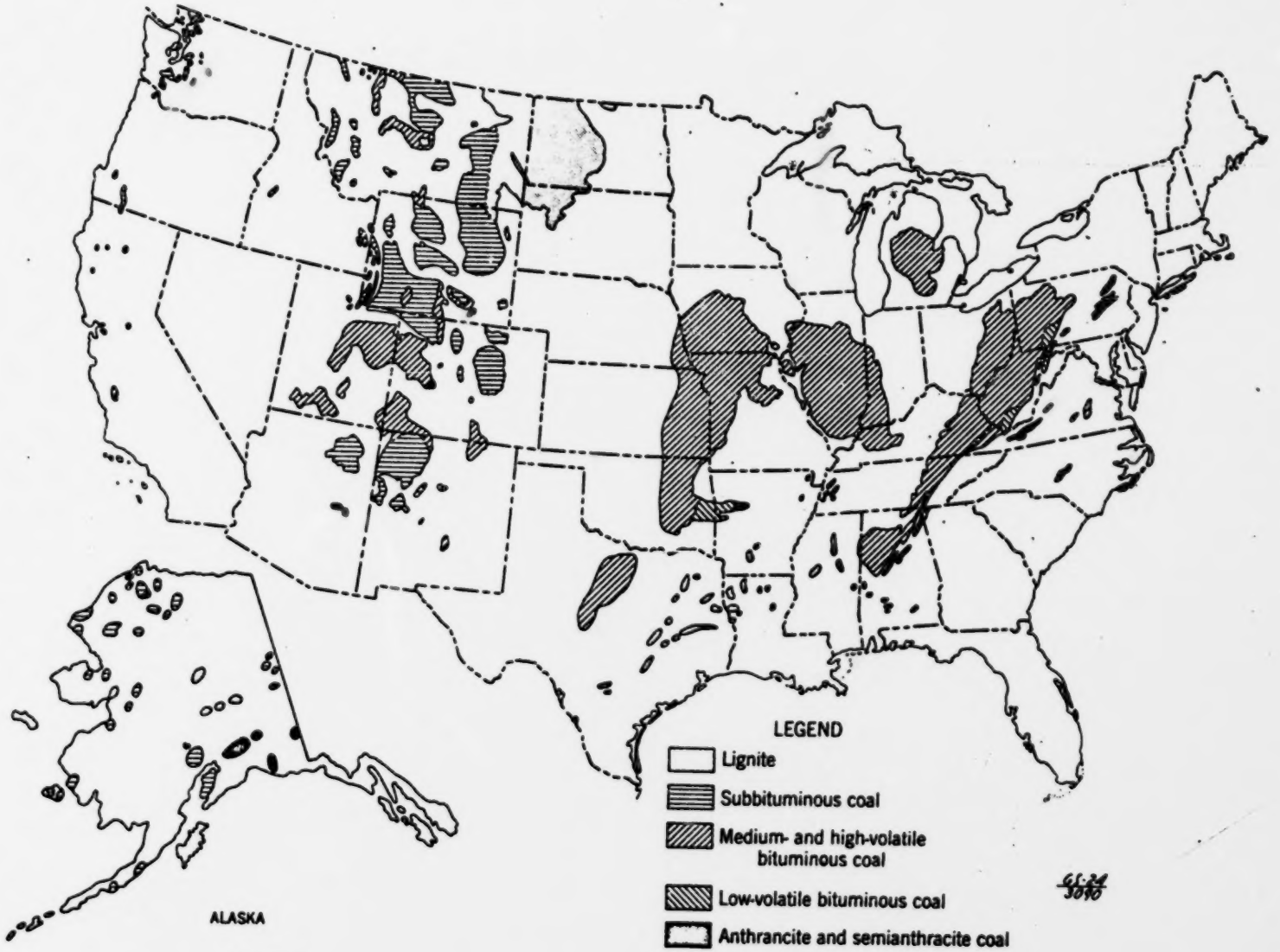

FIGURE 1. - Coalfields of the United States.